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भारतीय मानक

कार्य अध्ययन की तकनीकियाँ

भाग 2 कार्य मापन

Indian Standard

TECHNIQUES OF WORK STUDY

PART 2 WORK MEASUREMENT

UDC 65·015·14

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Management and Productivity Sectional Committee had been approved by the Management and Systems Division Council.

The aim of this standard is to promote the use of work measurement techniques in all fields of agricultural, industrial, commercial, service activity, etc, and thereby increase productivity.

Work Measurement is the application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance.

Work Measurement provides the management with a means of measuring the time taken in the performance of an operation or series of operations in such a way that ineffective time is separated from effective time. Work Measurement is a tool to be used to set standard times for carrying out the work. Figures 1, 2 and 3 taken from the book 'Introduction to Work Study' 3rd edition, International Labour Organization, illustrates the total time for an operation under the existing conditions indicating the basic work content and excess work content added due to different reasons graphically. Work content means, the amount of work 'contained in' a given product or process measured in man-hours or machine-hours.

Work measurement techniques may be applied to:

a) manufacturing and allied services like maintenance, stores, etc;
b) process industries;
c) offices; and
d) service organizations like banks, hospitals, hotels, transport, etc.

It is directly or indirectly applicable to industries, business, government and all other walks of life.

The time standards developed by the application of work measurement can be used for:

a) efficient comparisons (equipment and manpower),
b) work distribution/ manning of equipment,
c) operation planning, scheduling and control,
d) utilisation (equipment and manpower) including assembly/ production line balancing,
e) capacity calculations,
f) cost estimation of tenders/ contracts/ quotations, etc, and standard costs,
g) project/ activity duration estimation,
h) wage payment and incentive schemes,
j) economic justification of new machines and equipments,
k) method evaluation,
m) make or buy decision, and
n) manpower planning and forecasting.

The application of work measurement can also result in the improvement of methods and working conditions.

Method study should always precede work measurement to avoid certifying/justifying ongoing inefficient method. Study must be conducted with full knowledge of concerned persons including the operator being studied. The work measurement helps the Organization in improving its productivity to achieve leadership and a competitive edge in its own field.

Part 1 of this standard deals with the various techniques used in method study along with their methodology.

In preparing this standard, considerable assistance has been derived from the following publications:

International Labour Organization, Geneva, Introduction to Work Study [Third (revised) Edition].

Karger D.W. and Bayha Franklin H., Engineered Work Measurement (Second Edition).

Karger D.W. and Hancock H.A., Advanced Work Measurement.

Maynard H.B., Industrial Engineering Handbook.

Littlefield C.L., Management of Office Operations.

Zandin K.B., MOST Work Measurement System (Third Edition).

The committee responsible for the formulation of this standard is given in Annex H.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

TECHNIQUES OF WORK STUDY

PART 2 WORK MEASUREMENT

1 SCOPE

This standard (Part 2) describes the methodology and basic techniques used in Work Measurement and also the method of establishing Standard Time.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard.

IS No.	*Title*
787 : 1956	Guide for interconversion of values from one system of units to another
6363 : 1972	Glossary of terms in work study

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 6363 : 1972 shall apply.

4 PROCEDURE

4.1 The basic steps of work measurement are:

a) Select,
b) Record,
c) Examine,
d) Measure,
e) Compile, and
f) Define.

4.1.1 *Select*

4.1.1.1 Selection of job for work measurement can be done as per the following guidelines:

a) New jobs.
b) Job not covered by work measurement techniques or there is a change in method.
c) Jobs having complaints about loose or tight time standards.
d) Incentive scheme is to be introduced.
e) Comparison is to be made between different methods.

4.1.1.2 *Selection criteria for work measurement engineer*

a) He must be qualified in Industrial Engineering.
b) He should be well versed in practice of work study with experience in relevant areas.
c) He must be fully trained in rating and other important aspects of the work measurement such as allowances, etc.
d) He should possess the following essential attributes:
    i) He must be open to new ideas/suggestions and willing to share the information collected about the job with the concerned persons.
    ii) Objective in his observations, judgment and analysis, he must be able to resist pressures from the management and union which go against his professional judgment.
    iii) He should not be biased.
    iv) Sincere and punctual so as to set an example for the employees.
    v) Power to convince.
    vi) Interpersonal skills and teamwork.
    vii) Inquisitive and innovative skills.
    viii) High degree of initiative.

4.1.2 *Record*

Record all the relevant data relating to the circumstances in which the work is being done, the methods and the elements of activity in them.

4.1.3 *Examine*

Examine the recorded data and the detailed breakdown critically to ensure that the most effective method and set of motions are being used and that unproductive and foreign elements are separated from productive elements.

4.1.4 *Measure*

Measure the quantity of work involved in each element, in terms of time, using the appropriate work measurement technique.

4.1.5 *Compile*

Compile the standard time for the operation, which in the case of stop-watch time study will include time allowances to cover relaxation, personal needs, etc.

4.1.6 *Define*

Define precisely the series of activities and method of operation for which the time has been compiled and issue the time as standard for the activities and methods specified.

All the above listed steps are required if a time is to be published as a standard. If the work measurement is being used only as a tool of investigation of ineffective time before or during a method study, or to compare the effectiveness of alternative methods, only the first four steps are likely to be needed.

5 IMPLEMENTATION OF WORK MEASUREMENT RESULTS

5.1 On completion of the work measurement, it calls for its implementation or installation. Installation can be divided into:

a) gaining acceptance of the change by the departmental supervisor/management.
b) gaining acceptance of the change by the workers involved and their representatives.
c) retraining, if required, of the workers to acquaint them about the new methods.
d) maintaining close monitoring of the progress of the job until satisfied that it is running as intended.

5.2 The extent to which the workers require training or retraining will entirely depend on the nature of the job. The concept of Learning Curve, the details for which are as given below, can be used in deciding about the level of training or retraining.

5.2.1 *Learning Curve*

5.2.1.1 *Introduction*

The performance of worker carrying out an assigned task does not automatically proceed at the optimum rate as established by different work measurement techniques. He goes through distinct learning phases before achieving that rate. He needs to be informed in advance the performance expected according to the set standards. Encouragement and guidance by supervisor and/or the method of payment also help in accelerating the learning process.

5.2.1.2 Learning is defined as the improvement in performance (reduction in cycle time) resulting from practice in the reinforcement region.

Predicting the rate at which employee learns a task so that he can perform and give necessary output at the desired pace, is made easier by the application of learning curve theory. Learning Curve equations generally take the form of

$$Y = KX^{-A}$$

where

Y = time for the Xth cycle,
X = the cycle number, and
K and A = a constant for any given situation, the value of which is determined by the learning rate.

5.2.1.3 According to research findings the learning process is broken down into two parts:

a) Threshold learning, and
b) Reinforcement learning.

In threshold part, the individual is learning the sequence of activities he has to do, whereas in reinforcement part (when he already knows the sequence), repetition improves his skill and ability to perform the task.

5.2.1.4 It has been found through studies that there is a substantial change in the number of times the eyes are used while the operators are learning. The number of eye fixations at the beginning is, on the average, 2.5 times the number which occurs after the person has attained the Methods Time Measurement (MTM) standard times. The learning curve equation after incorporating the concept of use of eyes is generally defined as:

$$T_N = K \times T_s \times N^{-a}$$

or

$$T_N = 2.5 \times T_s \times N^{-a}$$

where

T_N = time for the Nth cycle,
T_s = standard time in TMU,
N = cycle number, and
a = learning curve exponent.

The value of 'a' can be calculated as

$$a = \frac{\log_{10} K}{\log_{10} N_s} \quad (K = 2.5)$$

where N_s = number of cycles needed to attain the standard time.

A typical learning curve is given in Fig. 4. Here the standard time and the number of cycles needed to attain the standard time have been determined by use of MTM, a Predetermined Motion Time Study (PMTS) technique.

5.2.1.5 *Learning curve application*

a) In case of new product introductions or design/method changes, the learning time can be estimated.
b) Learning curve can be used as a tool in selection of operators and monitoring their performance.
c) In job shop situations, where batch quantities are low, learning curve concept can be used for predicting the actual time taken.

6 ROLE OF COMPUTERS IN WORK MEASUREMENT

6.1 The person involved in establishing time standards spends most of his time analyzing and developing work standards. The time he spends in the shop making studies is rather short. Not too many improvements can be made in this part of his work, except for planning the work to be studied so that it progresses without breaks or interruptions. However, on the clerical side, electronic aids can do the job faster, more accurately, and more economically. Statistical analysis can also be done easily with electronic aids. Making studies the electronic way requires a "work study machine" and a computer. To be universally useful, the work study machine should:

a) be applicable to stop-watch time study, predetermined time system-based standard data, work sampling, and the group timing technique.
b) eliminate the studyperson's calculating job.
c) give rapid and reliable records of useful information on a data storage media like floppy, tape, etc, to be used on computer.
d) be easy to use in all kinds of location and easily portable.
e) be reliable with regard to function and accuracy of measurement.
f) be simple to operate and capable of being used correctly with a reasonable amount of training.

6.2 Devices meeting these characteristics are available and being used by a few organizations. The portable work study machine has the facility to store information using different push-buttons in the shop floor, which is transferred to computer for further analysis and calculation of results.

7 TECHNIQUES

The techniques of Work Measurement covered under this standard are:

a) Time study (unrestricted and restricted work),
b) Production study,
c) Work sampling/Rated work sampling,
d) Group timing technique,
e) Predetermined Motion Time Systems (PMTS),
f) Maynard Operation Sequence Technique (MOST),
g) Standard data,
h) Analytical estimation, and
j) Time ladder/Time log.

7.1 Time Study

7.1.1 Time study is a work measurement technique for recording the time and rates of working for the elements of a specified job carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance.

7.1.2 Time study may be applied to determine the work content and standard time for a job and also to help in method improvement.

7.1.3 The exact procedure used in making time studies may vary somewhat depending upon the type of operation being studied and the use that is to be made of the data obtained. However, the steps that are generally required to complete a time study are given below.

7.1.3.1 *Secure and record information*

It is required to obtain and record all the information available about the job, the operator and the surrounding conditions, which is likely to affect the execution of the work. The information to be obtained may be grouped as follows:

a) Information to enable the study to be located and identified quickly when needed giving serial number, year, product, studyperson, etc.
b) Information to enable the product or part being processed to be identified accurately.
c) Information to enable the process, method, plant or machine to be accurately identified.
d) Information to enable the operator to be identified.
e) Duration of the study.
f) Working conditions.

7.1.3.2 *Break the job into elements and check the method*

Timing an entire job as one element is seldom satisfactory. Thus the job must be broken into different elements. An element is defined as a distinct part of a specified job selected for convenience of observation, measurement and analysis. Sequence of different elements required to perform a job or yield a production unit forms a work cycle. The studyperson records a complete description of the method, breaking down the operation into elements and examines the detailed breakdown to ensure that the most effective method and set of motions are being used to carry out the job. There are broadly eight different types of elements, namely, repetitive, occasional, constant, variable, manual, machine, governing, and foreign elements. They are defined as:

a) A repetitive element is an element which occurs in every work cycle of the job.

b) An occasional element is an element which does not occur in every work cycle of the job, but which may occur at regular or irregular intervals.
c) A constant element is an element for which the basic time remains constant whenever it is performed.
d) A variable element is an element for which the basic time varies in relation to some characteristics of the product, equipment or process.
e) A manual element is an element performed by a worker.
f) A machine element is an element automatically performed by a power-driven machine (or process).
g) A governing element is an element occupying a longer time than that of any other element which is being performed on machine tools.
h) A foreign element is an element observed during a study which, after analysis, is not found to be a necessary part of the job.

The breakdown of the job into elements is necessary:

a) to ensure that productive time is separated from unproductive time.
b) to permit the rate of working to be assessed more accurately than would be possible over an entire cycle as the operator may not be able to work with the same tempo throughout the entire cycle.
c) to enable different types of elements to be identified.
d) to enable elements involving a high degree of fatigue to be isolated and to make the allocation of fatigue allowances more accurate.
e) to facilitate the checking of the method so that the subsequent omission or insertion of the elements may be detected quickly.
f) to enable time values for frequently recurring elements to be extracted and used in the compilation of standard data.
g) to enable a detailed work specification to be produced.

There are some general rules concerning the way in which the job should be broken down into elements:

a) Elements should be easily identifiable, with definite beginning and ending and, if possible, the element may have start/stop of sound or light for easy identification.
b) Elements should be short as can be conveniently timed by a trained observer. Preferably the duration of an element should be between 6-30 centi-minutes.
c) As far as possible, elements particularly, manual ones, should be chosen so that they represent naturally unified and recognisably distinct segments of the operation.
d) Manual elements should be separated from machine elements.
e) Constant elements should be separated from variable elements.
f) Occasional and foreign elements should be timed separately.

It is a good practice that the elements should be checked through a number of cycles before timing begins.

7.1.3.3 *Calculation of number of cycles required to be timed*

The sample size (number of cycles to be timed) can be decided either by the use of statistical method or the conventional method.

In the statistical method, after taking a number of preliminary readings to arrive at the value of n', the following equation is used to calculate the sample size for 95.45% confidence level and a margin of error of ± 5% (commonly used values).

$$n = \left[\frac{40 \sqrt{n' \Sigma x^2 - (\Sigma x)^2}}{\Sigma x} \right]^2$$

where

n = sample size we wish to determine,
n' = number of readings taken in the preliminary study,
Σ = sum of values, and
x = value of the readings of elements.

The statistical method of determining the sample size is valid to the extent that the assumptions made in deriving the formula are valid, in other words, the observed variations in the readings are due to mere chance and are not made intentionally by the operator. The statistical method can be cumbersome, since a given work cycle is composed of several elements. As the sample size will vary with the readings for each element, we can arrive at different sample sizes for each element within a given cycle, unless of course the elements have more or less the same average. As a result, we may have to calculate the sample size, in the case of cumulative timing, by basing it on the element that will call for the largest sample size.

Many companies, for ease of calculations adopt a conventional guide as given below for the number of cycles to be timed, based on the total number of minutes per cycle:

Minutes per cycle	up to 0.10	to 0.25	to 0.50	to 0.75	to 1.0	to 2.0	to 5.0	to 10.0	to 20.0	to 40.0	Over 40
Number of cycles recommended	200	100	60	40	30	20	15	10	8	5	3

If consistency is observed in the readings, the number of cycles could be reduced. This can be confirmed by drawing cumulative average basic times for a constant element against cumulative number of observations. When the cumulative average basic time reaches a constant figure, it indicates that enough observations have been made. Here, it shall also be considered that extreme values of observations are excluded for better accuracy.

7.1.3.4 *Observe and record the time taken*

Once the elements have been selected and written down, measuring of the elements with a timing device (usually a stop-watch) and recording the time taken by the operator to perform each element of the operation can start. However, at this stage, once again, it shall be ensured that the concepts of qualified worker and rating are rightly understood for their right application. It is essential due to the fact that an inexperienced studyperson may get misled by a large number of rapid movements into believing that an operator is working at a high rate or may underestimate the rate of working of the skilled operator whose apparently slow movements are very economical of motion. Therefore, it is required that the persons who do time study shall undergo regular training in rating.

In carrying out the time study the question arises, which worker should be taken for study. Different jobs require different human abilities. Some demand alertness, concentration, visual acuity; others, physical strength; most, some acquired skill or special knowledge. The worker to be selected shall be a *qualified worker* which is defined as the one who is accepted as having the necessary physical attributes, the required intelligence and education, and has acquired the necessary skill and knowledge to carry out the work in hand to satisfactory standards of safety, quantity and quality.

The experienced worker, as against inexperienced worker, achieves smooth and consistent movements; acquires rhythm; responds more rapidly to signals; anticipates difficulties and is more ready to overcome them, carries out the task without giving the appearance of conscious attention, and is therefore more relaxed.

Even the selection of a qualified operator is made for a time study as people do not work consistently from day to day or even from minute to minute and the studyperson has to have some means of assessing the rate of working of the operator and relating it to standard pace. This process is known as *rating* and is defined as "the assessment of the worker's rate of working relative to the observer's concept of the rate corresponding to standard pace". *Standard performance* is in turn defined as "the rate of output which qualified workers will naturally achieve without over-exertion as an average over the working day or shift, provided that they know and adhere to the specified method and are motivated to apply themselves to their work". This performance is generally accepted as equivalent to the speed of motion of the limbs of a man of average physique walking without a load in a straight line on level ground at a speed of 6.4 kilometres per hour (4 miles per hour). This is a brisk business-like rate of walking, which a man of the right physique and well accustomed to walking might be expected to maintain, provided that he took appropriate rest pauses every so often. Again when one talks of rating, it is the effective speed with which the operator carries out the work which is rated. Judgment of effective speed can only be acquired through experience and knowledge of the operations being observed.

In order that a comparison between the observed rate of working and the standard rate may be made effectively, it is necessary to have a numerical scale against which to make the assessment. There are several scales of rating in use, the most common of which are those designated the 100-133 scale, the 60-80, the 75-100, and the British standard scale used (essentially a restatement of the 75-100 scale) which is the 0-100 scale. In India, most of the companies use the 100-133 scale, where 100 corresponds to the speed of the motion of the limbs of a man of average physique walking without a load in a straight line on level ground at a speed of 4.8 kilometres per hour (3 miles per hour) and is considered to be a *standard performance*. It is the usual practice to round off ratings to the nearest multiple of five on the scale.

Basic requirements for doing a time study call for equipments like a stop-watch, a study board, time study forms, calculator, measuring instruments, etc. Sample sheets of study forms which may be used are given in Annex A.

The timings are generally recorded by the use of stop-watch. These watches have graduations in one hundredth of a minute, that is in centi-minutes. The following methods of timing with the stop-watch are in practice:

a) *Cumulative timing*—In cumulative timing, the watch runs continuously throughout the study. It is started at the beginning of the first element of the first cycle to be timed and is not stopped until the whole study is completed. At the end of each element the watch reading is recorded. The times for individual elements are obtained by successive subtractions after the study is completed. The purpose of this procedure is to ensure that all the time during which the job is observed is recorded in the study.

b) *Flyback timing*—In flyback timing, the hands of the stop-watch are returned to zero at the end of each element and are allowed to start immediately, that is, at the beginning of the next element and the time for each element being obtained directly. The mechanism of the watch is never stopped and the hand immediately starts recording the time of the next element.

c) *Differential timing*—This is the third method of timing which is employed for short-element short-cycle work, and which may indeed be the only way of getting accurate timing with a stop-watch, for elements which are so very short that there is not enough time for the studyperson to read his watch and make a recording in his study sheet. With differential timing, elements are timed in groups, first including and then excluding each small element, the time of each element being obtained subsequently by subtraction.

The most commonly used method of stop-watch timing is the cumulative timing method for the following reasons:

a) Experience suggests that reasonable accuracy is achieved by the use of this method.

b) It does not matter if element times are occasionally missed by inexperienced observers, the overall time of the study will not be affected.

c) In assessing the working pace of the operator, it is less easy to fall into the temptation to adjust the rating to the time taken by the element than with the flyback method, since only watch readings and not actual times are recorded.

d) Workers and their representatives are likely to have greater faith in the fairness of time studies if they can see that no time could have been omitted.

However, in all the methods it is usual to take an independent check of the overall time, that is, elapsed time of the study using mostly the wrist-watch.

7.1.3.5 *Extending observed times to 'basic times'*

The basic time represents the time the element would take to perform (in the judgment of the observer) if the operator were working at the standard rate, instead of the faster or slower ones actually observed. It is calculated as,

Basic time = (Observed time) × (rating/standard rating)

If the studyperson's ratings were always impeccable, then the result should be [(observed time) × (rating)] = a constant. However, in actual practice, the multiple [(observed time) × (rating)] very rarely works out to be exactly a constant when taken over a large number of readings for various reasons such as variations in the work content of the element; inaccuracies in noting and recording observed times; inaccuracies in rating variations due to rating to the nearest five points.

7.1.3.6 *Determining the allowances*

The determination of allowances, a compensation in the form of time to meet and fulfil personal needs, environment and work requirements, is probably the most controversial part of work measurement. It is not easy to determine precisely the allowances needed for a given job. Therefore, attempt should be made for an objective assessment of the allowances that can be consistently applied to various elements of work or to various operations.

There are different types of allowances which are applied in different situations. The allowances which are most commonly applied are relaxation allowances, contingency allowances and policy allowances. Relaxation allowances are generally made up of two components, fixed allowances, which in general include allowances for basic fatigue and personal needs, and variable allowances which are given for different factors like stress, strain and environment. The tables to calculate relaxation allowances as given in Annex B may be referred to as an illustration to arrive at the relaxation allowances and not as a strict guideline. Each organization should develop its own scheme of relaxation allowance, taking into consideration the factors given in the example as an illustration.

Basic times calculated with lot of efforts should not be spoiled by the hasty or ill-considered addition of a few percentage points as allowances and neither shall the allowances be used as 'loosening' factors.

7.1.3.7 *Determining the standard time for the operation*

Once the basic time is calculated and a decision on allowances is taken, it is possible to obtain a complete picture of the standard time for a straightforward manual job or operation. The standard time for the job will be the sum of the standard times for all the elements of which it is made up of, due regard being paid to the frequency with which the elements recur plus the allowances. In other words, standard time is the total time in which a job should be completed at standard performance.

7.1.4 *Advantages*

a) Single operators/machines and short cycle repetitive work can be easily studied;

b) Time study permits an extremely fine breakdown of activities and delays;

c) An aid in improving methods;

d) A high degree of reliability in data is obtained; and

e) High level of acceptance by the management and union.

7.1.5 *Disadvantages*

a) For each and every operator to be studied at a time, a separate studyperson is required;

b) Extremely rigorous process and hence time consuming and costly;

c) Changes of day-to-day or week-to-week variations not easy to account; and

d) It is necessary to use trained studyperson as rating calls for experience and accurate judgment.

7.1.6 *Precautions*

a) It must be ensured that the method is right and at any one time reference should be made to only one specific method;

b) Studies must be taken on qualified workmen;

c) On no account should any attempt be made to time the operator without his knowledge, from a concealed position or with the watch in the pocket;

d) All the information must be recorded while taking observations. The recording may be made using pencil or pen or ballpen;

e) Allowances shall be decided judiciously and consistently; and

f) Studyperson shall be well trained and experienced in conducting time study. The person shall undergo regular training to keep himself/herself up-to-date with the rating concepts. A relatively new person shall conduct the studies under the guidance and supervision of an experienced person.

7.1.7 *Unrestricted and Restricted Work*

7.1.7.1 Time standards can be compiled for all jobs in which the operator works with hand tools or with power tools which he himself manoeuvers, as distinct from machines which perform part of the operation automatically. Such work is known as unrestricted work, because the output of the worker is limited only by factors within his control. The work in which the output of the worker is limited by factors outside his control is known as restricted work. A common example of restricted work occurs when an operator is running a single machine and the machine works automatically for part of the work cycle. Other examples of restricted work occur when:

a) One or more operators are running several machines;

b) Operators are in control of process, their principle duty being to observe the behaviour of the process or instruments recording their behaviours and to take action only in response to change in behaviour, state or reading; and

c) Two or more operators are working as a team, dependent on one another and it proves impossible to completely balance the work load of each, with the result that some workmen are left with periods of idleness within the work cycle.

7.1.7.2 The period during which the machine is working is known as the 'machine controlled time'. However, the operator may carry out part of his manual work while the machine is stopped, and part while it is running. These parts are called 'outside work' and 'inside work', respectively. Finally, there is the time during which the operator is waiting for the machine to complete the work, that is, his 'unoccupied time'.

7.1.7.3 In order to set time standards for such operations, which are considered to be part of restricted work, it is necessary to apply somewhat different methods in extension of the above mentioned basic time procedures.

a) In restricted work, it is essential that the personal needs allowance and the fatigue allowance be calculated separately. This is because personal needs are calculated not on the elements of manual work alone but on the whole of the cycle time. Fatigue allowance, on the other hand, is calculated only for elements of manual work.

b) If the work cycle is a very long one, and there are lengthy periods of unoccupied time within it (say 10 to 15 minutes), where the operator can also leave his workplace, it may be possible in certain circumstances for the whole of the personal needs allowance and the fatigue allowance to be taken within the cycle. Short periods (say 1.5 minutes or longer) of unoccupied time can be used for recovery from fatigue, provided that the operator during that period can freely relax and is not required to be constantly on the alert or to give attention to the machine, and also that he has a seat nearby.

c) Four cases can be distinguished which affect the way in which relaxation allowances must be treated for restricted work based on the length of the cycle and the manner in which any inside work occurs.

    i) All the personal needs allowance and all the fatigue allowance must both be taken outside the working cycle.

    ii) The personal needs allowance must be taken outside the cycle, but the fatigue allowance can be taken within it.

    iii) The personal needs allowance and some of the fatigue allowance must be taken outside the cycle, but the rest of the fatigue allowance can be taken within it.

    iv) All the personal needs allowance and all the fatigue allowance can be taken within the working cycle.

7.1.7.4 In case of multiple machine working or team working (with or without machines), the work studyperson has first to examine the methods of working by drawing multiple activity charts, with the object of devising a sequence of operations which will result in the best balance and thus the least interference, and then to use time study techniques to measure the amount of interference which will occur even when the best sequence has been determined. The concept of interference/machine interference is defined as the queuing of machines (or processes) for attention, for example, when one worker is responsible for attending to more than one machine. Similar circumstances arise in team work where random delays at any point may affect the output of the team. To cover this time, interference allowance is defined as an allowance of time for production unavoidably lost through synchronization of stoppages on two or more machines (or processes) attended by one worker. Similar circumstances arise in team work.

7.1.7.5 Thus the overall cycle time in which the job shall be completed at standard performance in case of restricted work will be made up of outside work at standard pace, machine controlled time and any portion of the relaxation allowance which has to be allowed outside the machine controlled time, contingency allowance, and interference allowance.

7.2 Production Study

A production study is a time study carried out over a specified period of time, usually at least half-a-day or one shift, for the purpose of:

a) ascertaining the frequency and duration of activities;

b) ascertaining ineffective time of irregular or infrequent occurrence; and

c) checking an existing time standard.

The purpose of production study is to make sure that nothing that occurs during the working period is overlooked. They are especially concerned with interruptions; work of an occasional nature and ineffective time due to any cause which is not likely to appear in ordinary time studies; set-up time for the machines of longer duration; allowances, etc.

Same forms as used for time study can be used for production study. The elements are rated and the standard time is calculated as in time study.

7.3 Work Sampling

7.3.1 *Definition*

Work sampling is a technique used to measure and analyze the work without the use of a stop-watch. The technique is based on the law of probability and was introduced in England by L.H.C. Tippett in 1934. The technique works because it is statistically confirmed that a smaller number of chance occurrences tend to follow the same distribution pattern which a larger number produces. The simple example used to illustrate this point is that of tossing a coin. In this exercise, greater the number of tosses, better is the chance of arriving at a figure of 50% heads and 50% tails or in other words, greater the number of tosses, lesser will be the error or magnitude of uncertainity.

This technique is also known by other names like ratio-delay study, activity sampling, random observation method, snap-reading method, observation ratio study.

7.3.2 *Application*

a) To study time utilization or ineffective time in a job of one or more resources.

b) To determine the work content and standard time for a job.

The technique can be used for manufacturing, service or office operations.

7.3.3 *Procedure*

The procedure for work sampling should broadly follow the steps which are given below.

7.3.3.1 *Define the problem*

Before making actual observations it is important to decide the objective of work sampling. This could range from simply determining if the machine is working or idle or to get further details on each or few of the factors under working or non-working category.

7.3.3.2 *Prepare an observation recording form for the job*

The form to be used for recording the observations for work sampling study has to be designed depending on the type of job to be observed. Its design will depend upon the number of work stations or people to be observed and the classification of the activities upon which it is desired to obtain data. A typical format is attached as Annex C.

7.3.3.3 *Select the frequency of observations*

Three factors need to be kept in mind while deciding the frequency of observations:

a) *Nature of the operation*—If the job is of shortcycle operations in which all the desired elements occur frequently, the observations can be spread out over a period of time. If it is a non-repetitive operation or one where some elements occur infrequently, it is better to make more observations per day. This improves the chances of getting better details.

b) *Physical limits*—If the route to be followed for taking observations is going to be long and there is just one observer to make the observations, he will be able to make relatively few observations in a day.

c) *Total number of observations required and the time limit*—If 1 000 observations are needed and there are only 10 working days to make them, it is evident that an average of 100 observations a day will be needed.

7.3.3.4 *Determine time of trips*

Trips can be determined based on random basis or on a fixed interval basis. Deciding on random samples which follow no set pattern is often difficult. The safest way is to use a table of random numbers (a random table as an example is given in Annex D) because the human mind has a tendency to follow a set pattern. Various types of random tables exist and can be used in different ways. Help of computers may also be taken in generating random samples.

7.3.3.5 *Estimate the number of observations needed*

This information is critical to plan the frequency, number of observers and length of the study. The number depends on how accurate the answers need to be. There are mainly two methods used to pre-estimate the number of observations needed to give the practical accuracy required, namely, Statistical method and Nomogram method.

In order to calculate the number of observations in both the methods, it is required to decide on two of the parameters, that is confidence level and margin of error. The basic assumption made in both the methods is that the observations follow normal probability distribution. To describe these curves, two attributes that is average as measure of central tendency and the deviation from the average, referred to as standard deviation are used.

a) *Confidence level*—In the example of tossing of coin, it has been observed that the larger the size of the sample, the more accurate or representative it becomes with respect to the original 'population', or group of items under consideration. It can therefore be visualized as a scale where, at one end, there can be complete accuracy achieved by continuous observation and, at the other end, very doubtful results derived from a few observations only. The size of the sample is therefore important, and we can express the confidence in whether or not the sample is representative by using a certain *confidence level.*

   It can be said that if we take a large sample at random we can be confident that in 95% of the cases our observations will fall within ±1.96 times standard deviation, and so on for the other values.

b) *Margin of error*—As well as defining the confidence level for our observations we have to decide on the margin of error that we can allow for these observations. We must be able to say that for 95% of the times this particular observation is correct within ± 5% or ±10% or whatever other range of accuracy we may decide on.

Statistical Method

The formula used in this method is

$$s = \sqrt{\frac{p\,(100-p)}{N}}$$

where

s = standard error of proportion,
p = percentage of occurrence, and
N = number of observations.

Before we can use this formula, however, we need to have at least an idea of the value of p. The first step is therefore to carry out a preliminary study taking number of random observations in the working area to calculate approximate value of p. Having the approximate value of p and in order to determine the value of N, it is required to find out the value of standard error of proportion.

If we choose a confidence level of 95% with a 5% margin of error, the standard error of proportion will be:

$1.96\,s = 5$ or $s = 2.5$ (approx)
(for a Normal Distribution Curve)

It can seen from the formula that by reducing or increasing the margin of error the sample size can be increased or reduced.

Nomogram Method

To facilitate faster computations, John M. Allderige, in his article "Work Sampling Without Formula", recommends the use of alignment charts to determine the number of observations to meet the needed precision requirement. A sample of this chart is enclosed as Annex E

7.3.3.6 *Make the observations*

It should be clear at the beginning of the study what information is required and why. Ambiguity in classifying activities should be avoided. The recording itself consists simply of making a stroke or tally mark in front of the appropriate activity on the record sheet in each observation round.

7.3.3.7 *Check the accuracy of data at the end of each day*

It has been observed that the activity under consideration tends towards a constant value as the number of observation are increased, provided stable conditions in the work place prevail. This can be seen by drawing a control chart of percent of occurrence on day-to-day basis.

The stability analysis may also be carried out with accumulated observations on day-to-day basis. This chart may also be used as an empirical method of determining the length of the study. When the variation from day-to-day is reduced to the desired level for the element chosen to control the study, it can be assumed that enough observations have been gathered.

7.3.3.8 *Compile results, implement, maintain and improve*

A summary table for the entire study shall be prepared. This gives an overall picture. The analysis of results can be calculated readily on the record sheet. It is possible to find out the percentage of effective time compared with that of delays, to analyze the reasons for ineffective time and to ascertain the percentage of time spent by a workman, group of workmen or a machine on a given element.

7.3.4 *Advantages*

a) Helps obtain facts at a lower cost than that of continuous observation. A simultaneous work sampling study of several operators or machines may be made by a single observer.
b) Does not require observers with special skill and training. Require little observer training. However, the observer should be familiar with the type of work to be observed.
c) Causes fewer complaints from individuals under study than continuous observation.
d) Causes less distortion in the individuals normal work route than continuous observation.
e) Observations may be taken over a period of days or weeks, thus decreasing the chance of day-to-day or week-to-week variations affecting results.
f) A work sampling study may be interrupted at any time without affecting results and are less fatiguing and less tedious to make.
g) No stop-watch or other timing device is needed for work sampling studies.

7.3.5 *Disadvantages*

a) It is not economically feasible to use work sampling on short-cycle and highly repetitive jobs because in these cases traditional methods can usually develop job standards less expensively.
b) An extremely large number of observations will have to be taken to achieve a desired accuracy as work sampling follows the laws of probability. Hence such studies takes a considerable length of time.

c) Work sampling is essentially a passive technique based on recording what an observer observes. It lacks the aggressive attitude towards methods and does not enforce constructive method study as do Predetermined Time Standards (PTS) such as Methods Time Measurement (MTM).

d) The inter-relationship among the operator, machine and material are not easy to identify.

e) Management and workmen may not understand statistical work sampling as readily as they do time study.

f) There is a tendency on the part of some observers to minimize the importance of following the fundamental principles of work sampling, such as proper sample size for a given degree of accuracy, randomness in making observations, instantaneous observations at the preassigned location, and carefully defining the elements or sub divisions of work or delay before the study is started.

g) The operator may change his work pattern upon the sight of the observer. If this happens, the results of such a work sampling is of little value.

7.3.6 *Precautions*

a) Trips must be made at random.

b) The objective of the work sampling study must be clearly defined.

c) The technique must be explained to the persons concerned before the study.

7.3.7 *Rated Work Sampling*

Many times the personnel being sampled through work sampling are performance rated. In these cases, the activities are not only considered as working/non-working but they are also rated. This is done to ensure that the working time is calculated as near as possible to the actual time. This method is employed to measure work and establish norms in situations where other techniques are difficult to use or are not economically viable. The time in this case is calculated as:

Standard Time = [(Actual hours in study) ×
(% utilized) ×
(average rating)]

To these elements are added the unrated elements or allowances, which may be adjusted according to policy decisions relating to personnel and idle time, allowable instruction time, and the like.

7.4 Group Timing Technique

7.4.1 Group timing technique (GTT) is a work measurement procedure for multiple activities that enables one observer using a stop-watch to make a detailed elemental time study on two to fifteen men or machines at the same time. Continuous elemental observations are made at predetermined fixed intervals and are recorded as tally marks on a form listing the elements of the job. Elements that will vary in time because of operator performance may be levelled. Either or both elemental time values and percentage allowances, including fatigue, may be established from a single group timing technique study or series of studies.

7.4.2 The proper interval size is primarily dependent on the number of operators or objects and their location. The intervals that an observer can use comfortably during the study are given below:

Number of Workers in Group	*Interval Measured on Stop-Watch (Decimal Minute Watch)*
1	Use time study or MTM
2	0.5 minute
3-6	1.0 minute
7-10	2.0 minutes
11-15	3.0 minutes
Over 15	Use 2 or more observers

7.4.3 Several factors influence the length of the study. The minimum number of total observations or observations for the critical activity can be computed using the statistical formulae as given below:

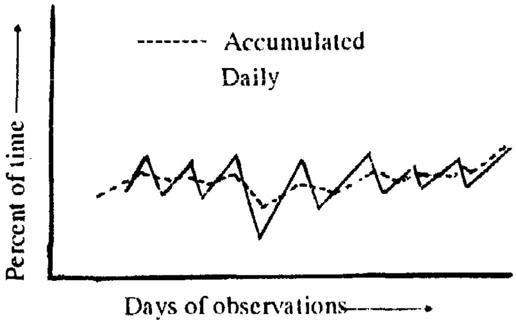
$$N = \frac{6\,400 \times i \times t \times C_a}{rT_a^2 \times t_a^2}$$

$$Na = \frac{6\,400 \times i \times C_a}{rT_a^2 \times t_a}$$

where

T = total length (time) of study,
T_a = total time for activity a,
t = time for one work cycle,
t_a = time for one occurrence of activity a,
N = total number of observations,
N_a = total number of observations for activity a,
C_a = number of occurrences during one work cycle for activity a,
i = interval size, and
rT_a = relative error for T_a at the 95% confidence level.

Continuous check on the daily and accumulated values of one or more critical activities by plotting of diagrams such as shown below should be helpful in determining the stability of conditions and evaluating the necessary duration of the study.



7.4.4 GTT studies look so much like work sampling studies that they could easily but mistakenly pass as such. In both cases, samples are taken that permit drawing certain conclusions about the nature of the population from which they are taken. The apparent difference of fixed versus random observation intervals, relates the two methods to entirely different statistical mathematical models and thus the formulae for the computation of number of observations in each method are different. Generally, for the same level of accuracy and all other features being equal, GTT normally calls for a considerably smaller number of observations than work sampling.

7.4.5 This technique is also known as 'systematic activity sampling', 'fixed interval study' and the like.

7.5 Predetermined Motion Time Study (PMTS)

7.5.1 *Genesis*

Frederick W. Taylor, the father of time study, wrote in the latter part of the nineteenth century that, to establish an operation standard, it was necessary to subdivide the operation into the elements of work, write a description of each element of work, time each element of work with a stop-watch and add certain allowances to cover unavoidable delays and fatigue.

Several years after Taylor began his work with time study, Frank B. Gilbreth, the father of motion study began his technique of using motion picture camera to study the motions required to perform certain tasks. Gilbreth subdivided the Taylor elements in to basic motions which he called therbligs. These therbligs were used to build up the operation standard in much the same way that Taylor used his elements to build up an operation standard.

The expansion of Taylor and Gilbreth methods has resulted in predetermined elemental times for a great many factory operations. Predetermined elemental times using basic Gilbreth developments are for motions rather than for elements of specific operations. Well-known techniques using this approach are called:

a) Methods Time Measurement (MTM),
b) Work Factor (WF),
c) Motion Time Analysis (MTA), and
d) Basic Motion Time Study (BMT).

However amongst all the above techniques MTM is widely used in developed countries.

7.5.2 *Definitions*

PMTS is a procedure in which all manual motions are analytically subdivided into the basic elements required for their performance and predetermined time values are assigned to the basic elements:

a) Motion is the movement of human body or any of the body member.
b) Manual element is a distinct, describable and measurable subdivision of a work cycle or operation performed by one or more human motions that are not controlled by process or machine.
c) Basic element is the smallest element of human activity or inactivity used in any particular system of motion analysis.

7.5.3 *Applicability*

Some of the important areas where use of PMTS is found to be very useful in reducing cost through better methods are:

a) Developing effective methods in advance of beginning production;
b) Improving existing methods;
c) Establishing time standards;
d) Estimating;
e) Guiding product design;
f) Developing effective tool design;
g) Selecting effective equipment;
h) Operator training;
j) Settling grievances; and
k) Training supervisors to become method-conscious.

7.5.4 *Selection Criteria*

In order to analyze a method with one of predetermined time systems, the study of each motion involved in the performance of operator's method is required. In PMTS, cycle time can be reduced by reducing the number of motions and/or degree of control required to perform the motions. These reductions in motion help in:

a) increasing the operators safety;

b) increase in operators comfort; and

c) reduction in physical effort and fatigue.

7.5.5 *Methodology*

7.5.5.1 *Procedure*

By visualizing the movements necessary to perform the operation effectively:

a) Determine the best workplace layout;

b) Determine the type and position of tools;

c) Develop the instruction sheet for training the operator in best method; and

d) Where machine time is necessary it is added to the motion time to get cycle time per unit.

7.5.5.2 *Format*

Workplace layout and MTM analysis sheet are given in Annex F.

7.5.5.3 *Tools*

a) MTM card, giving time values in TMU (Time Measuring Units). 1TMU = 10^{-5} h. An example is given in Annex G.

b) Calculator, etc.

7.5.5.4 *Precaution*

Person applying PMTS techniques should know how to refer MTM cards and should be able to distinguish between various motions.

7.5.5.5 *Personal eligibility*

This technique should be used only by 'MTM Practitioners Card Holders' given by MTM Association for Standards and Research, 16-01, Broadway, Fair Lawn NJ 07410.

7.6 Maynard Operation Sequence Time (MOST)

7.6.1 *Introduction*

MOST is the latest work measurement technique, which aims at simplification of the Industrial Engineer's task of analyzing and estimating work content. MOST stands for Maynard Operation Sequence Technique.

Adequate accuracy, combined with high application speed and simplicity are some of the advantages of MOST.

For the overwhelming majority of work there is a common factor from which work can be studied that is the displacement of objects. MOST, therefore, concentrates on the movement of objects.

7.6.2 *Features*

7.6.2.1 *High application speed*

MOST is much faster than other techniques because of its simpler construction. Predetermined motion time systems are traditionally based on assigning selected time values to minute human motions. MOST does not require that operation be broken down into such details. Instead, MOST groups together the basic motions that frequently occur in sequence. Sequence models are preprinted on the analysis form, leaving the analyst with the task of filling in only the variable index numbers. It is found that MOST is 4 to 40 times faster than the other PMTS techniques.

7.6.2.2 *Accuracy*

The accuracy principles that apply to MOST are the same as those used in statistical tolerance control. MOST time values are based on calculations that ensure the overall accuracy of the final time standard.

7.6.2.3 *Reduced documentation*

Reduced paperwork is one of the major advantages of MOST. While reducing paperwork, MOST retains the clarity of definition of the method describing the activity in clear, concise and plain language.

7.6.2.4 *Method sensitivity*

MOST sharply recognises the sensitivity of a time standard to the method used, hence it is possible to quickly revise a standard in cases where methods are proposed to be changed. MOST highlights elements which are more time consuming indicating scope for method improvement.

7.6.2.5 *Consistency*

Through the use of the sequence model approach, analysts are aided in making the correct decisions. The result is smaller deviations among analysts compared to other predetermined motion time systems. MOST concentrates on the movement of objects.

7.6.3 *The Basic Sequence Models*

7.6.3.1 *The general move sequence*

For the free movement of an object in space through air under manual control.

This sequence model generally follows a fixed sequence of sub activities identified by following steps:

a) Reach with one or two hands a distance to the object(s), either directly or in conjunction with body motions.

- b) Gain manual control of the object.
- c) Move the object in a temporary or final position.
- d) Return to workplace.

The sequence model is having three distinct phases: GET, PUT and RETURN. The MOST analyst should strictly adhere to this 3-phase breakdown.

The sequence is:

A B G A B P A
(ABG) is GET
(ABP) is PUT
(A) is RETURN

The alphabets/letters are the subactivities or parameters of the sequence model.

A = Action distance
B = Body motion
G = Gain control
P = Place

Indexing of the parameters or attaching time value is strictly in accordance with the work content involved in performing the subactivity or parameter. The MOST analyst will have to refer the data-cards available to assign the correct index value.

A general move sequence model after assigning index values looks like:

A1 B0 G1 A1 B0 P3 A0

To calculate the time required to perform above task add all the index values and multiply by 10.

$1 + 0 + 1 + 1 + 0 + 3 + 0 = 6$

$6 \times 10 = 60$ TMUs.

7.6.3.2 *The controlled move sequence*

For the movement of an object when it remains in contact with a surface or is attached to another object during the movement.

The controlled move sequence follows a fixed sequence of subactivities identified by following steps:

- a) Reach with one or two hands a distance to the object(s) either directly or in conjunction with body motions.
- b) Gain manual control of the object.
- c) Move the object over a controlled path.
- d) Allow time for a process to occur.
- e) Align the object following the controlled move or at the conclusion of the process time.
- f) Return to workplace.

The sequence model is having three distinct phases: GET, MOVE or ACTUATE, RETURN. The MOST analyst should strictly adhere to this 3-phase breakdown.
The sequence is:

A B G M X I A
(ABG) is GET.
(MXI) is MOVE or ACTUATE.
(A) is RETURN.

A = Action distance
B = Body motion
G = Gain control
M = Move controlled or actuate
X = Process time
I = Align

A controlled move sequence model after assigning index values looks like:

A6 B0 G3 M3 X0 I6 A0

To calculate the time required to perform above task add all the index values and multiply by 10.

$6 + 0 + 3 + 3 + 0 + 6 + 0 = 18$

$18 \times 10 = 180$ TMUs.

7.6.3.3 *The tool use sequence*

For the use of common hand tools.
The tool use sequence is composed of subactivities from the general move sequence along with specially designed parameters describing the actions performed with hand tools or in some cases the use of certain mental processes like:

Fasten	(F)
Loosen	(L)
Cut	(C)
Surface Treat	(S)
Measure	(M)
Record	(R)
Think	(T)

The tool use sequence follows a fixed sequence of subactivities identified by following steps:

- a) Get object or tool.
- b) Place object or tool in working position.
- c) Use tool.
- d) Put aside object or tool.
- e) Return to workplace.

The sequence is:

A B G A B P ? A B P A
(ABG) is get object or tool.
(ABP) is place object or tool.
(?) is the appropriate parameter for use tool.
(ABP) is aside object or tool.
(A) is return.

A controlled move sequence model after assigning index values looks like:

A1 B0 G1 A1 B0 P3 F16 A1 B0 P1 A0

To calculate the time required to perform above task add all the index values and multiply by 10.

1 + 0 + 1 + 1 + 0 + 3 + 16 + 1 + 0 + 1 + 0 = 24
24 × 10 = 240 TMUs.

7.6.4 *Special Sequences in MOST*

Three more special sequences have been developed for analyzing work content involved in moving heavy objects by material handling equipments.

a) Manual Crane Sequence,
b) Powered Crane Sequence, and
c) Truck Sequence.

7.7 Standard Data

7.7.1 *Introduction*

Many operations in a given plant have several common elements. The job of work studyperson would be much easier if he had at his disposal a set of data from which he could readily derive standard times for these common work elements without necessarily going into elements and then referring to the standard data bank to derive the normal times for each element, one would calculate the total time needed to perform this new job and determine its standard time by adding the appropriate allowances in the usual way.

7.7.2 *Major Considerations*

Following considerations are important while developing standard data.

7.7.2.1 *Coverage*

It may be difficult to cover the entire range of operations simultaneously. In practice it is better to restrict the number of jobs normally to one or more departments in a plant, or to all the processes involved in manufacturing certain products. In this way the coverage becomes more manageable.

7.7.2.2 *Reliability*

The reliability of the data can be increased if:

a) sufficient data is collected for each element, and
b) as many common elements as possible are grouped together.

7.7.2.3 *Source of elemental time data*

The source of time data could be:

a) Previous time studies, or
b) PMTS (Predetermined Motion Time Systems).

7.7.2.4 *Users' needs*

Standard data is to be built with due regard to users' needs which vary considerably depending upon the purpose (among them production planning, cost estimation, incentive payments and budgetary control).

7.7.3 *Developing the Standard Data*

The following steps should be taken to develop standard data:

a) Decide the extent of coverage;
b) Break the job into elements through job analysis;
c) Decide the type of reading, for example, previous studies or PMTS or combination of both;
d) Determine the major factors that are likely to affect the time, for example, shape and size, weight handled, distance moved, force applied, etc; and
e) Measure the time from direct observations. Decide elemental time values for various values of above factors.

   The studyperson can choose arbitrary distances and times taken by various workers to cover and then take average. The studyperson will then find it more appropriate to draw a curve to indicate the relationship between the time and distance covered. For example, the average time for walking the distance from 10 m to 40 m is arrived at as follows:

   A graph or nomogram can be plotted for elemental time *v/s* different values of the factor. The time for an element 'Pick up part', for example, can be plotted for different weights of the part. A formula can also be developed for different weights of the part. A formula also can be developed for this purpose.

f) Create appropriate document to facilitate easy reference and use of the data so developed.
g) The data is then used for building up time standards.
h) Continuously update the standard data bank to include:
   i) new elements, and
   ii) refine existing elemental times through larger number of observations.

7.8 Analytical Estimation

7.8.1 *Introduction*

In this technique, the time required to carry out elements at a defined rate of working is estimated partially from knowledge and practical experience of the work concerned and partially from data available from historical records.

7.8.2 *Methodology*

For those elements, where elemental time data is available, it is used straight away and for other elements, time is assessed or estimated analytically using knowledge and practical experience of the work concerned. The craftsmen, skilled and experienced in the work concerned, should be engaged as estimators.

Basic orientation fn work study is necessary. For this purpose analysis of historical records concerning work outputs, time taken and various variations thereof may be undertaken to arrive at time standards.

7.8.3 *Need for use of Analytical Estimation*

The setting of reasonably accurate time standards for non repetitive work has always been a problem in industry. It is often quite uneconomical to use time study to do so.

However, analytical estimation can be extensively used in field of plant maintenance, repair work and project work. It can also be used in jobbing shops for estimating production time. The result can be used for the same purpose as those derived from other techniques of work measurement.

7.9 Time Ladder/ Time Log/ Activity Logging

7.9.1 *Introduction*

This may be used by asking office staff to maintain a record (log) of the details of the activities at a regular time interval throughout and for a sufficiently long period along with output of each activity. This gives the time estimates for each activity. The technique can be used for setting office standards.

7.9.2 *Methodology*

Following steps are involved in setting time standards using this technique:

a) Develop definitions of the activities that the employees are to record and codify;
b) Explain how the study is to be conducted, what record must be kept and how long the study is to continue;
c) Design the forms to be used in collecting the data. A typical time log form is shown in Annex A. The table shows the workday divided into minutes and the activities are recorded as and when they occur. In order to record the time spent on various work categories, the employee simply draws a line across the duty column of the time log, whenever a change is made from one activity to another. He then inserts the proper activity code and the number of units processed; and
d) Summarize the recorded times and units processed and develop time standards for each activity.

7.9.3 *Advantages*

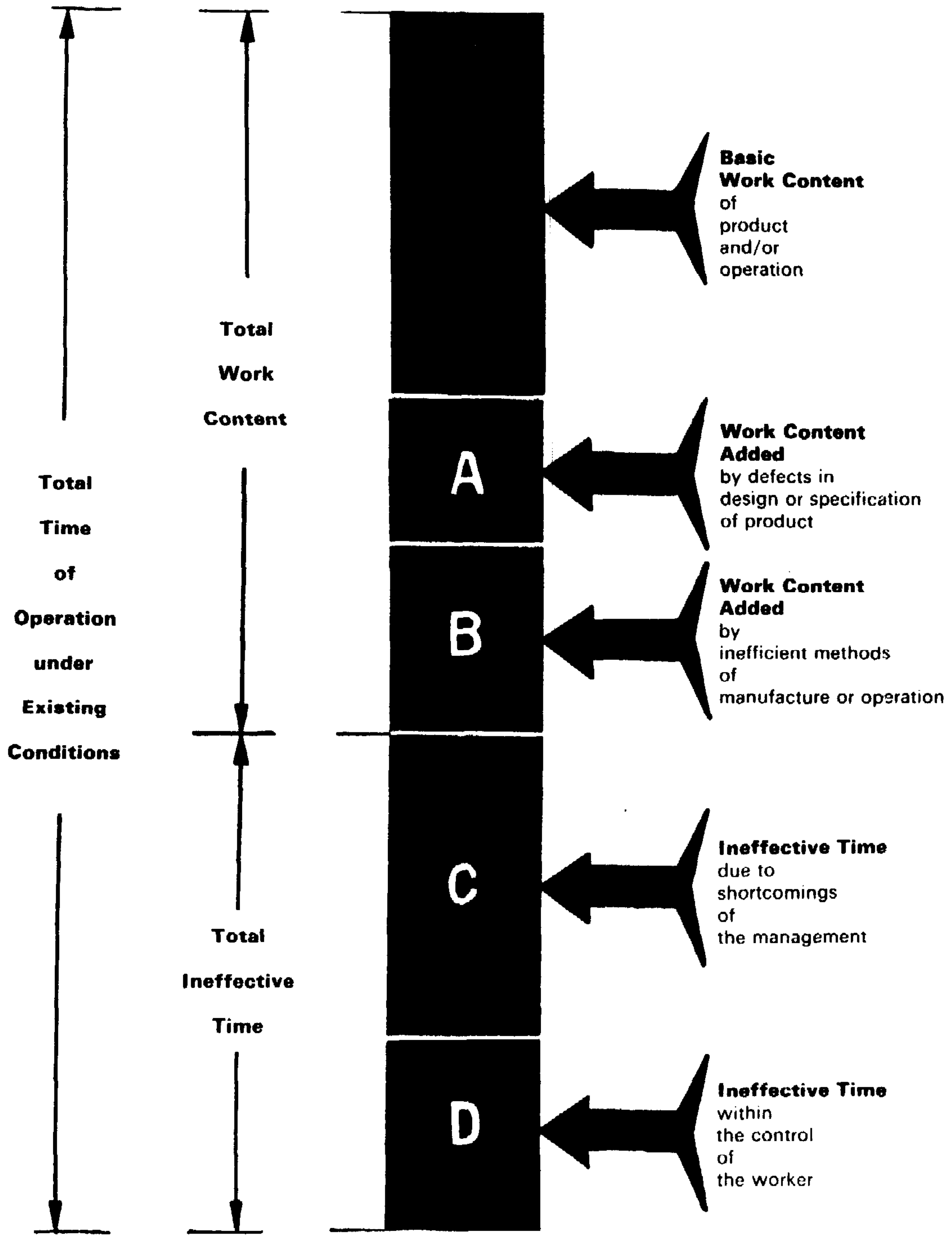
a) It is easy to explain and administer;
b) Employees generally are stimulated to higher performance by knowing that some effort is being made to keep the score;
c) It is less expensive; and
d) It is likely to meet favourable response from employees as compared to other techniques.

7.9.4 *Disadvantages*

It sets standards by averaging the times obtained in past performance, but not based on what could or should be done.

7.9.5 *Precautions*

Even past performance data derived from time logs can be refined. This might be done by relying more upon that of average workers by adjusting average figures before setting time standards, and by maintaining records of production experience and method changes, through which higher standards might later be justified.



NOTE — In the B. S. Glossary the terms 'work content' and 'ineffective time' are accorded precise technical meanings which differ slightly from those used here. The *Glossary* definitions are intended for use in applying work measurement techniques, and are not strictly relevant to the present discussion. In this chapter and the next, 'work content' and 'ineffective time' are used with their ordinary common meanings as defined in the text.

FIG. 1 HOW MANUFACTURING TIME IS MADE UP

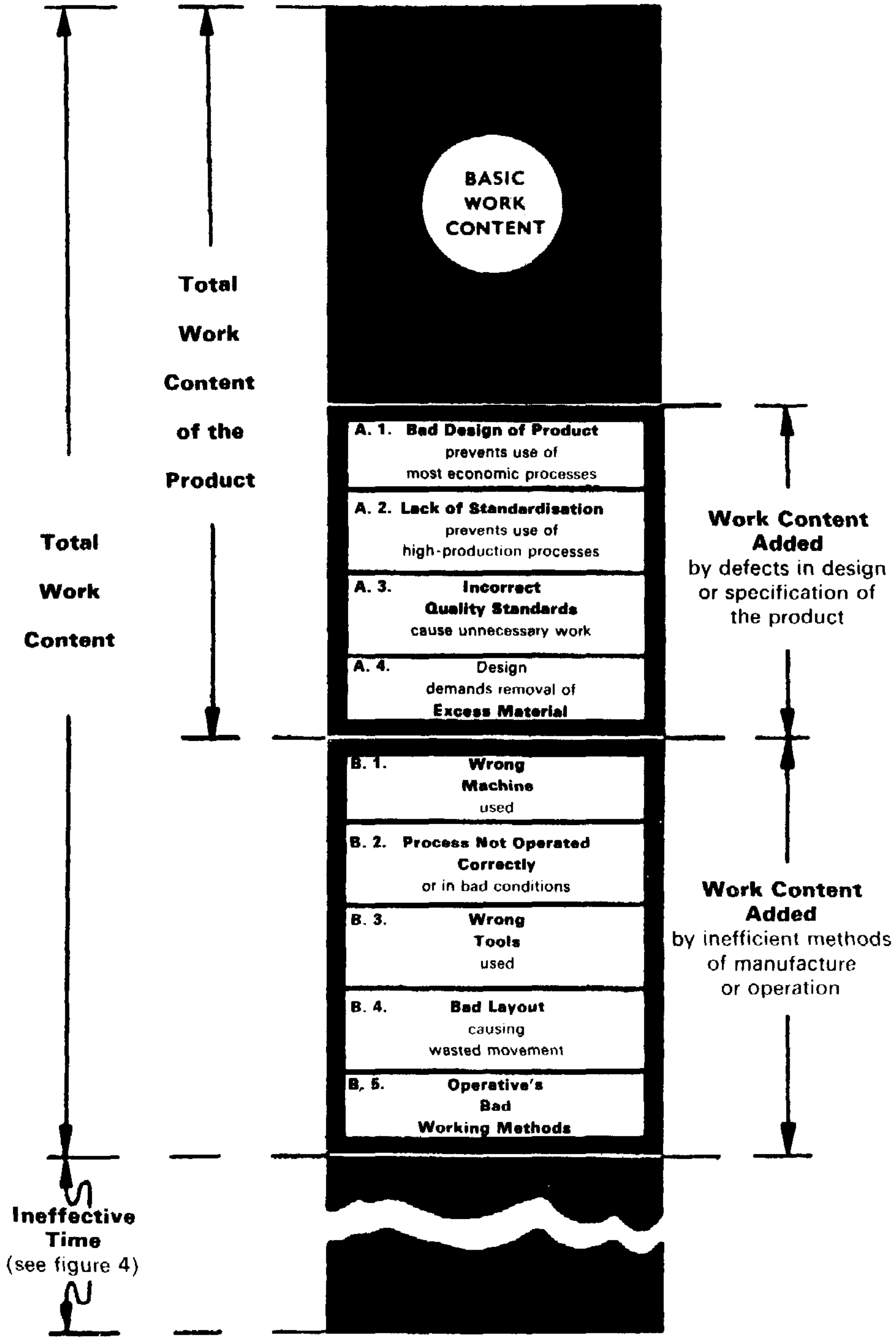
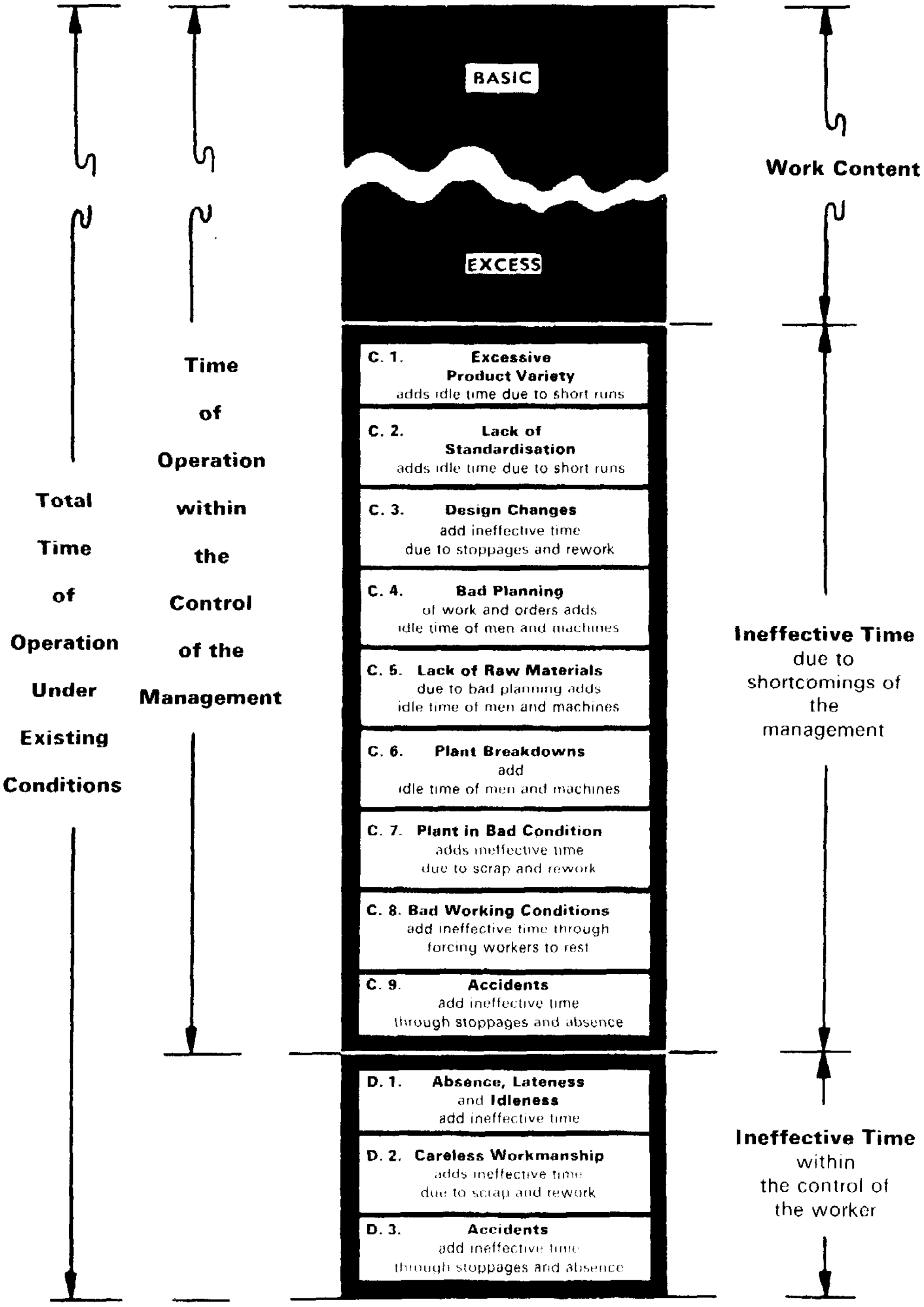

BASIC WORK CONTENT
Total Work Content of the Product
Total Work Content
A. 1. Bad Design of Product prevents use of most economic processes
A. 2. Lack of Standardisation prevents use of high-production processes
A. 3. Incorrect Quality Standards cause unnecessary work
A. 4. Design demands removal of Excess Material
Work Content Added by defects in design or specification of the product
B. 1. Wrong Machine used
B. 2. Process Not Operated Correctly or in bad conditions
B. 3. Wrong Tools used
B. 4. Bad Layout causing wasted movement
B. 5. Operative's Bad Working Methods
Work Content Added by inefficient methods of manufacture or operation
Ineffective Time (see figure 4)

FIG. 2 WORK CONTENT DUE TO THE PRODUCT AND PROCESSES


BASIC
EXCESS
Work Content
Total Time of Operation Under Existing Conditions
Time of Operation within the Control of the Management
C. 1. Excessive Product Variety adds idle time due to short runs
C. 2. Lack of Standardisation adds idle time due to short runs
C. 3. Design Changes add ineffective time due to stoppages and rework
C. 4. Bad Planning of work and orders adds idle time of men and machines
C. 5. Lack of Raw Materials due to bad planning adds idle time of men and machines
C. 6. Plant Breakdowns add idle time of men and machines
C. 7. Plant in Bad Condition adds ineffective time due to scrap and rework
C. 8. Bad Working Conditions add ineffective time through forcing workers to rest
C. 9. Accidents add ineffective time through stoppages and absence
Ineffective Time due to shortcomings of the management
D. 1. Absence, Lateness and Idleness add ineffective time
D. 2. Careless Workmanship adds ineffective time due to scrap and rework
D. 3. Accidents add ineffective time through stoppages and absence
Ineffective Time within the control of the worker

NOTE "Idle time" is used here in the ordinary sense of the term, not that defined in the B.S. *Glossary*.

FIG. 3 INEFFECTIVE TIME DUE TO SHORTCOMINGS ON THE PART OF MANAGEMENT AND WORKERS

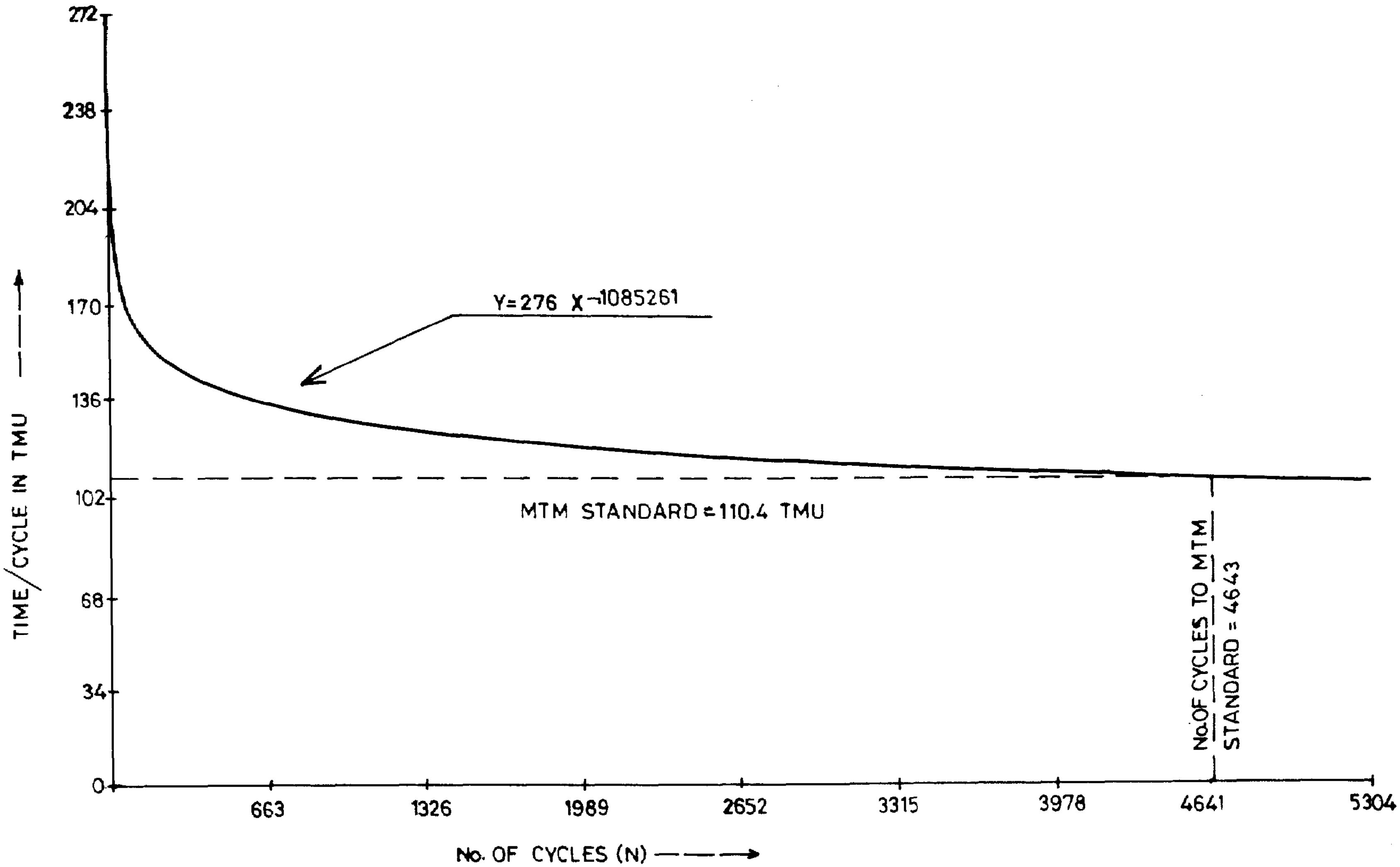


FIG. 4 LEARNING CURVE OPERATION : BIMETAL WIRE CUTTING AND LOOPING

ANNEX A

(*Clause* 7.1.3.4)

TIME STUDY FORMS

A-1 TIME LOG SHEET

DEPT : PAPER DIVISION
SECTION : OFFICE

DATE : 05.08.91
PERSON : SHRI. S. LAL
POSITION : SECRETARY

TIME (h)	UNITS*	ACTIVITY CODE	TIME (h)	UNITS*	ACTIVITY CODE
0800-0815 0815-0830 0830-0845	1	A	1200-1215 1215-1230	5	D
0845-0900 0900-0915 0915-0930	2	C	1230-1245 1245-1300 1300-1315 1315-1330	3	C
0930-0945 0945-1000	1	B	1330-1345 1345-1400	1	E
1000-1015 1015-1030 1030-1045 1045-1100	—	G	1400-1415 1415-1430 1430-1445 1445-1500	2	F
1100-1115 1115-1130	1	F	1500-1515 1515-1530 1530-1545 1545-1600	1	A
1130-1145 1145-1200	1	A			

	SUMMARY	
Activity Code	Units	Time (Min)
A	3	135
B	1	30
C	5	105
D	5	30
E	1	30
F	3	90
G	—	60
TOTAL		480

*Units is a value of quantified output like number of vouchers processed, letters typed, files handled, etc.

A-2 GENERAL-PURPOSE TIME STUDY TOP SHEET

TIME STUDY TOP SHEET

DEPARTMENT:

OPERATION: M.S. NO.:

PLANT/MACHINE: NO.:

TOOLS AND GAUGES:

PRODUCT/PART: NO.:
DWG. NO.: MATERIAL
QUALITY:

STUDY NO.:
SHEET NO.: OF

TIME OFF:
TIME ON:
ELAPSED TIME:

OPERATIVE:
CLOCK NO.:

STUDIED BY:
DATE:
CHECKED:

N.B. Sketch the WORKPLACE LAYOUT/SET-UP/PART on the reverse, or on a separate sheet and attach.

ELEMENT DESCRIPTION	R.	W.R.	S.T.	B.T.	ELEMENT DESCRIPTION	R.	W.R.	S.T.	B.T.

N.B. R. = Rating W.R. = Watch Reading S.T. = Subtracted Time B.T. = Basic Time

A-3 CONTINUATION SHEET FOR GENERAL-PURPOSE TIME STUDY (FRONT)

STUDY NO.:	TIME STUDY CONTINUATION SHEET					SHEET NO.:		OF	
ELEMENT DESCRIPTION	R.	W.R.	S.T.	B.T.	ELEMENT DESCRIPTION	R.	W.R.	S.T.	B.T.

N.B. Reverse side similar, but without upper line of heading.

A-4 SHORT CYCLE STUDY FORM (FRONT)

DATE OF STUDY ______	TIME FINISHED ______ TIME STARTED ______ ELAPSED TIME ______	SHORT CYCLE STUDY SHEET	STUDY NO : SHEETS ______ OF ______ SHEETS

DEPARTMENT ______ OPERATION: ______ TOOLS USED: ______	PART NAME ______ DWG. NO : ______ PART NO.: ______ SPEED: rev/min ______ FEED: ______ mm/min ______	BASIC CYCLE TIME ______ min OR TOTAL AVE. ELEMENT TIME ______ min RATING FACTOR ______ BASIC CYCLE TIME ______ min
MACHINE AND NO. : ______ OPERATED AUTO ☐ FOOT ☐ HAND ☐ MATERIAL	STANDARD ______ ______ ______	REASON FOR STUDY ORIGINAL STUDY ☐ METHOD STUDY CHANGE ☐ TO CHECK ESTB. STANDARD ☐

ALLOWANCES [PERSONAL % / DELAY % / FATIGUE % / OTHERS %] % — min

STANDARD TIME PER PIECE ______ min

WORK PLACE LAYOUT	**DESCRIPTION OF METHOD**
	REMARKS:

A-5 SHORT CYCLE STUDY FORM (BACK)

DATE OF STUDY	TIME FINISHED ____ TIME STARTED ____ ELAPSED TIME ____	SHORT CYCLE STUDY SHEET	STUDY NO.: ____ SHEETS ____ OF ____ SHEETS

ELEMENT NO.	1	2	3	4	5	6	7	8	9	10	NAME OF OPERATIVE ____		
STANDING ☐ SITTING ☐ MOVING ☐ ABOUT											CLOCK NO. ____ OBSERVED BY ____ APPROVED BY ____ FOREIGN ELEMENTS ____		
CYCLE NO.											SYMBOL		DESCRIPTION
1											A		
2											B		
3											C		
4											D		
5											E		
6											F		
7											G		
8											H		
9											I		
10											J		
11											K		
12											L		
13											M		
14											N		
15											O		
16											P		
17											Q		
18											R		
19											S		
20											T		
TOTAL													
NO. of Obs.													
AVERAGE													
RATING %													
BASIC TIME													

A-6 TIME STUDY FORM

STUDY NO.:		SHEET OF	
FIXTURES, TOOLS, JIGS, GAUGES	NO.	DESCRIPTION	NO.
		PRODUCT/COMPONENT	
		OPERATION	
		MACHINE	
		DEPARTMENT	
		OPERATOR	
		TOTAL NORMAL CYCLE TIME	
		ALLOWANCES	
MATERIAL		STANDARD TIME IN MINUTES PER CYCLE	
MACHINE SPEED		STANDARD TIME IN MINUTES PER PIECE	

ROUGH SKETCH AND BRIEF DESCRIPTION OF PRESENT AND PROPOSED METHOD

STUDIED BY DATE	CHECKED BY DATE

A-7 SNAP BACK/CONTINUOUS WATCH METHOD

TO
FROM
ELAPSED TIME

TIME STUDY DETAILS

SHEET NO.

ELEMENT	1	2	3	4	5	6	7	8	9	10	AVERAGE N.T.
N.T.											
R.											
O.T.											
W.R.											

FOREIGN ELEMENTS

FROM	TO	ELAPSED TIME	DESCRIPTION	FROM	TO	ELAPSED TIME	DESCRIPTION

A-8 STUDY SUMMARY SHEET

DEPARTMENT:	SECTION:	STUDY NO. SHEET NO. OF:
OPERATION:	M.S. NO.:	DATE:
		TIME OFF:
PLANT/MACHINE:	NO.:	TIME ON:
		ELAPSED TIME:
		CHECK TIME:
TOOLS & GAUGES:		NET TIME:
PRODUCT/PART:	NO.:	OBS. TIME:
DWG NO.:	MATERIAL:	UNACC. TIME:
		U.T. AS %
QUALITY:	WORKING CONDITIONS:	STUDIED BY: CHECKED BY:
OPERATIVE:	M/F CLOCK NO.	

Sketch and Notes on back of Sheet 1

EL. NO.	ELEMENT DESCRIPTION	B.T.	F.	Obs.	

N.B. B.T. = Basic Time F. = Frequency of occurrence per cycle Obs. = No. of observations

ANNEX B

(*Clause* 7.1.3.6)

EXAMPLE OF TABLES USED TO CALCULATE RELAXATION ALLOWANCES

B-0 This Annex is based on information supplied by Peter Steele and Partners (United Kingdom). Similar tables have been developed by various institutions, such as REFA (Federal Republic of Germany) and by other consulting firms.

B-1 Relaxation allowances may be determined by means of the tables of comparative strains and the points conversion table reproduced in this appendix. The analysis should proceed as follows:

a) For the element of work under consideration, determine the severity of the strain imposed under each sub-heading of the table of strains below, by reference to the tables of comparative strains.

b) Allocate points as indicated and determined the total points for the strains imposed by the performance of the element of work.

c) Read off from the points conversion table the appropriate relaxation allowance.

B-2 TABLES OF COMPARATIVE STRAINS

B-2.1 Physical Strains Resulting from the Nature of the Work

B-2.1.1 *Average Force Exerted* [*Strain A* (*see Table 1*)]

Consider the whole of the element or period for which the relaxation allowance is required and determine the average force exerted.

Example:

Lift and carry a weight of 40 lb (time 12 seconds) and return empty-handed (time 8 seconds). In this example, if the relaxation allowance is to apply to the full 20 seconds, the "average force exerted" should be calculated as follows:

$$\left(40 \times \frac{12}{20}\right) + \left(0 \times \frac{8}{20}\right) = 24 \text{ lb.}$$

NOTE — The values given in the above example are in pounds (lb), which may be converted into kilogram by using the following conversion factor:

1 lb = 0.453 592 4 kg

or

1 kg = 2.204 622 lb as given in IS 787 : 1956

The number of points allocated for the average force exerted will depend upon the type of stress involved. Stresses are classified as follows:

a) *Medium stress*
  i) Where the work is primarily concerned with carrying or supporting loads; and
  ii) Shovelling, swinging hammers and other rhythmical movements.

This category covers most operations.

b) *Low stress*
  i) Where the weight of the body is transferred in order to exert force, for example foot-pedal operation; pressing an article, with the body, against a buff; and
  ii) supporting or carrying well balanced loads strapped to the body or hung from the shoulders; arms and hands free.

Table 1 Points Allocated for Various Strains: Summary

(*Clause* B-2.1.1)

Type of Strain	Severity		
	Low	*Medium*	*High*
A. *Physical strains resulting from nature of work*			
1. Average force exerted	0-85	0-113	0-149
2. Posture	0-5	6-11	12-16
3. Vibration	0-4	5-10	11-15
4. Short cycle	0-3	4-6	7-10
5. Restrictive clothing	0-4	5-12	13-20
B. *Mental strains*			
1. Concentration/anxiety	0-4	5-10	11-16
2. Monotony	0-2	3-7	8-10
3. Eye strain	0-5	6-11	12-20
4. Noise	0-2	3-7	8-10
C. *Physical or mental strains resulting from nature of working conditions*			
1. Temperature			
Low humidity	0-5	6-11	12-16
Medium humidity	0-5	6-14	15-26
High humidity	0-6	7-17	18-36
2. Ventilation	0-3	4-9	10-15
3. Fumes	0-3	4-8	9-12
4. Dust	0-3	4-8	9-12
5. Dirt	0-2	3-6	7-10
6. Wet	0-2	3-6	7-10

NOTE — Allocate points for each strain independently, irrespective of what has been allowed for other strains. If any strain occurs for only a proportion of the time, allocate a similar proportion of the points.

For example : High concentration = 16 points, 25 percent of the time;
Low concentration = 4 points, 75 percent of the time;
Allocate 16 × 0.25 = 4 points plus 4 × 0.75 = 3 points, which gives a total of 4 + 3 = 7 points.

c) *High stress*

   i) Where the work is primarily concerned with lifting;

   ii) Exerting the force by continued use of certain muscles of fingers and arms;

   iii) Lifting or supporting loads in awkward attitudes, manipulation of heavy weights into awkward positions; and

   iv) Operations in hot conditions, hot metalworking, etc.

   Relaxation allowances should be awarded in this category only after every endeavour has been made to improve facilities which will make the physical task lighter.

A study should be made of the elements in relation to low, medium and high stress conditions. The points to be allocated, according to the type of stress and the average force applied, are set out in Tables 2 to 4.

Table 2 Medium Stress: Points for Average Force Exerted
(*Clause* B-2.1.1)

lb.	0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	3	6	8	10	12	14
10	15	16	17	18	19	20	21	22	23	24
20	25	26	27	28	29	30	31	32	32	33
30	34	35	36	37	38	39	39	40	41	41
40	42	43	44	45	46	46	47	48	49	50
50	50	51	51	52	53	54	54	55	56	56
60	57	58	59	59	60	61	61	62	63	64
70	64	65	65	66	67	68	69	70	70	71
80	72	72	72	73	73	74	74	75	76	76
90	77	78	79	79	80	80	81	82	82	83
100	84	85	86	86	87	88	88	88	89	90
110	91	92	93	94	95	95	96	96	97	97
120	97	98	98	98	99	99	99	100	100	100
130	101	101	102	102	103	104	105	106	107	108
140	109	109	109	110	110	111	112	112	112	113

Table 3 Low Stress: Points for Average Force Exerted
(*Clause* B-2.1.1)

lb.	0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	3	6	7	8	9	10
10	11	12	13	14	14	15	16	16	17	18
20	19	19	20	21	22	22	23	23	24	25
30	26	26	27	27	28	28	29	30	31	31
40	32	32	33	34	34	35	35	36	36	37
50	38	38	39	39	40	41	41	42	42	43
60	43	43	44	44	45	46	46	47	47	48
70	48	49	50	50	50	51	51	52	52	53
80	54	54	54	55	55	56	56	57	58	58
90	58	59	59	60	60	60	61	62	62	63
100	63	63	64	65	65	66	66	66	67	67
110	68	68	68	69	69	70	71	71	71	72
120	72	73	73	73	74	74	75	75	76	76
130	77	77	77	78	78	78	79	80	80	81
140	81	82	82	82	83	83	84	84	84	85

Table 4 High Stress: Points for Average Force Exerted
(*Clauses* B-2.1.1 *and* B-4)

lb.	0	1	2	3	3-4	4	5	6	7	8	9
0	0	0	0	3	6	8	11	13	15	17	18
10	20	21	22	24		25	27	28	29	30	32
20	33	34	35	37		38	39	40	41	43	44
30	45	46	47	48		49	50	51	52	54	55
40	56	57	58	59		60	61	62	63	64	65
50	66	67	68	69		70	71	72	73	74	75
60	76	76	77	78		79	80	81	82	83	84
70	85	86	87	88		88	89	90	91	92	93
80	94	94	95	96		97	98	99	100	101	101
90	102	103	104	105		105	106	107	108	109	110
100	110	111	112	113		114	115	115	116	117	118
110	119	119	120	121		122	123	124	124	125	126
120	127	128	128	129		130	130	131	132	133	134
130	135	136	136	137		137	138	139	140	141	142
140	142	143	143	144		145	146	147	148	148	149

Example: If the weight carried is 25 lb:

i) determine the type of stress involved (medium, low or high);

ii) in the left-hand column of the table for the type of stress (Table 2, 3 or 4), find the line for 20 lb;

iii) on this line, move across the table to the right, to col 5;

iv) read off the points allocation for 25 lb carried, which is :
Table 2, medium stress : 30 points;
Table 3, low stress : 22 points; and
Table 4, high stress : 39 points.

B-2.1.2 *Posture (Strain A.2)*

Consider whether the worker is sitting, standing, stooping or in a cramped position and whether a load is handled easily or awkwardly.

	Points
Sitting easily	0
Sitting awkwardly, or mixture of sitting and standing	2
Standing or walking freely	4
Ascending or descending stairs unladen	5
Standing or walking with a load	6
Climbing up or down ladders, or some bending, lifting, stretching or throwing	8
Awkward lifting, shovelling ballast to container	10
Constant bending, lifting, stretching or throwing	12
Coalmining with pickaxes, lying in a low seam	16

B-2.1.3 *Vibration (Strain A.3)*

Consider the impact of the vibration on the body, limbs or hands and the addition to mental effort due to it, or to a series of jars or shocks.

	Points
Shovelling light materials	1
Power sewing-machine Power press or guillotine if operative is holding the material Cross-cut sawing	2
Shovelling ballast Portable power drill operated by one hand	4
Pickaxing	6
Power drill (two hands)	8
Road drill on concrete	15

B-2.1.4 *Short Cycle (Highly Repetitive) (Strain A.4)*

In highly repetitive work, if a series of very short elements form a cycle which is continuously repeated for a long period, award points as indicated below, to compensate for the lack of opportunity to vary the muscles used during the work.

Average cycle time (centi-minutes)	*Points*
16-17	1
15	2
13-14	3
12	4
10-11	5
8-9	6
7	7
6	8
5	9
Less than 5	10

B-2.1.5 *Restrictive Clothing (Strain A.5)*

Consider the weight of the protective clothing in relation to effort and movement. Consider also whether ventilation and breathing are affected.

	Points
Thin rubber (surgeon's) gloves	1
Household rubber gloves Rubber boots	2
Grinder's goggles	3
Industrial rubber or leather gloves	5
Face mask (for example, for paint-spraying)	8
Asbestos suit or tarpaulin coat	15
Restrictive protective clothing and respirator	20

B-2.2 Mental Strains

B-2.2.1 *Concentration/Anxiety (Strain B.1)*

Consider what would happen if the operative relaxed his attention, the responsibility carried, the need for exact timing of movements, and the accuracy or precision required.

	Points
Routine simple assembly Shovelling ballast	0
Routine packing, labourer washing vehicles Wheeling trolley down clear gangway	1
Feed press tool; hand clear of press Topping up battery	2
Painting walls	3
Assembling small and simple batches, performed without much thinking Sewing machine work, automatically guided	4
Assembling warehouse orders by trolley Simple inspection	5
Load/unload press tool, hand feed into machine Spray-painting metal work	6
Adding up figures Inspecting detailed components	7
Buffing and polishing	8
Guiding work by hand on sewing-machine Packing assorted chocolates, memorising pattern and selecting accordingly Assembly work too complex to become automatic Welding parts held in jig	10
Driving a motor bus in heavy traffic or fog Marking out in detail with high accuracy	15

B-2.2.2 *Monotony (Strain B.2)*

Consider the degree of mental stimulation and if there is companionship, competitive spirit, music, etc.

	Points
Two men on jobbing work	0
Cleaning own shoes for half an hour on one's own	3
Operative on repetitive work Operative working alone on non-repetitive work	5
Routine inspection	6
Adding similar columns of figures	8
One operative working alone on highly repetitive work	11

B-2.2.3 *Eye Strain (Strain B.3)*

Consider the lighting conditions, glare, flicker, illumination, colour and closeness of work and for how long the strain is endured.

	Points
Normal factory work	0
Inspection of easily visible faults Sorting distinctively coloured articles by colour Factory work in poor lighting	2
Intermittent inspection for detailed faults Grading apples	4
Reading a newspaper in a motor bus	8
Arc-welding using mask Continuous visual inspection, for example cloth from a loom	10
Engraving using an eyeglass	14

B-2.2.4 *Noise (Strain B.4)*

Consider whether the noise affects concentration, is a steady hum or a background noise, is regular or occurs unexpectedly, is irritating or soothing. (Noise has been described as "a loud sound made by somebody else".)

	Points
Work in a quiet office, no distracting noise Light assembly factory	0

	Points
Work in a city office with continual traffic noise outside	1
Light machine shop Office or assembly shop where noise is a distraction	2
Woodworking machine shop	4
Operating steam hammer in forge	5
Rivetting in a shipyard	9
Road drilling	10

B-2.3 Physical or Mental Strains Resulting from the Nature of the Working Conditions

B-2.3.1 *Temperature and Humidity (Strain C.1)*

Consider the general conditions of atmospheric temperature and humidity and classify as indicated below. Select points according to average temperature within the ranges shown:

Humidity	*Temperature*		
(Percent)	Up to 75°F*	76° to 90°F*	Over 90°F*
Up to 75	0	6-9	12-16
76-85	1-3	8-12	15-26
Over 85	4-6	12-17	20-36

*1° F = 0.555 555 6°C
or 1°C = 1.8°F

B-2.3.2 *Ventilation (Strain C.2)*

Consider the quality and freshness of the air and its circulation by air-conditioning or natural draught.

	Points
Offices Factories with "office-type" conditions	0
Workshop with reasonable ventilation but some draught	1
Draughty workshops	3
Working in sewer	14

B-2.3.3 *Fumes (Strain C.3)*

Consider the nature and concentration of the fumes: whether toxic or injurious to health ; irritating to eyes, nose, throat or skin; disagreeable odour.

	Points
Lathe turning with coolants	0
Emulsion paint Gas cutting Soldering with resin	1
Motor vehicle exhaust in small commercial garage	5
Cellulose painting	6
Moulder procuring metal and filling mould	10

B-2.3.4 *Dust (Strain C.4)*

Consider the volume and nature of the dust.

	Points
Office Normal light assembly operations Press shop	0
Grinding or buffing operations with good extraction	1
Sawing wood	2
Emptying ashes	4
Linishing weld	6
Running coke from hoppers into skips or trucks	10
Unloading cement	11
Demolishing building	12

B-2.3.5 *Dirt (Strain C.5)*

Consider the nature of the work and the general discomfort caused by its dirty nature. This allowance covers "washing time" where this is paid for (that is, where operatives are allowed three minutes or five minutes for washing, etc). Do not allow both points and time.

	Points
Office work Normal assembly operations	0
Office duplicators	1
Dustman	2
Stripping internal combustion engine	4
Work under old motor vehicle	5
Unloading bags of cement	7
Coalminer Chimney-sweep with brushes	10

B-2.3.6 *Wet (Strain C.6)*

Consider the cumulative effect of exposure to this condition over a long period.

	Points
Normal factory operations	0
Outdoor workers, for example, postman	1
Working continuously in the damp	2
Rubbing down walls with wet pumice block	4
Continuous handling of wet articles	5
Laundry wash-house, wet work, steamy, floor running with water, hands wet	10

B-3 POINTS CONVERSION TABLE

B-3.1 If the total number of points allocated for the various strains is 37:

a) in the left-hand column of Table 5, find the line for 30;

b) on this line, move across the table to the right, to col 7;

c) read off the relaxation allowance for 37 points, which is 18 percent.

B-4 EXAMPLES OF CALCULATION OF RELAXATION ALLOWANCES (*See* Table 4)

B-4.1 Power Press Operation

As press guard opens automatically, reach in with left hand, grasp piece-part, and disengage it. With left hand move piece-part to tote bin, while right hand places new blank in press tool. Withdraw right hand, while left hand closes guard. Operate press with foot. Simultaneously, with right hand reach to tote bin, grasp blank and orient it in hand, move blank near guard and wait for guard to open.

On 20-ton press. Maximum reach 50 cm (20 in.). Posture somewhat unnatural; seated at machine. Noisy department, adequate lighting.

B-4.2 Carry 50 lb. Sack up Stairs

Lift sack on to bench 90 cm (3 ft.) high; transfer to shoulder, carry up stairs, drop sack on floor. Dusty conditions.

B-4.3 Pack Chocolates

In three layers of 4 lb. box, according to pattern for each layer, average 160 chocolates. Operative sits in front of straight shelves bearing 11 kinds of chocolates in trays or tins; he must pack the chocolates according to a memorised pattern for each layer. Air-conditioned, good light.

Table 5 Percentage Relaxation Allowance for Total Points Allocated
(*Clause* B-3.1)

Points	0	1	2	3	4	5	6	7	8	9
0	10	10	10	10	10	10	10	11	11	11
10	11	11	11	11	11	12	12	12	12	12
20	13	13	13	13	14	14	14	14	15	15
30	15	16	16	16	17	17	17	18	18	18
40	19	19	20	20	21	21	22	22	23	23
50	24	24	25	26	26	27	27	28	28	29
60	30	30	31	32	32	33	34	34	35	36
70	37	37	38	39	40	40	41	42	43	44
80	45	46	47	48	48	49	50	51	52	53
90	54	55	56	57	58	59	60	61	62	63
100	64	65	66	68	69	70	71	72	73	74
110	75	77	78	79	80	82	83	84	85	87
120	88	89	91	92	93	95	96	97	99	100
130	101	103	105	106	107	109	110	112	113	115
140	116	118	119	121	122	123	125	126	128	130

Table 6 Calculation of Relaxation Allowances : Examples
(*Clause* B-4)

Type of Strain	Job					
	Power Press Operation		*Carrying 50 lb. Sack*		*Packing Chocolates*	
	Stress	Points	Stress	Points	Stress	Points
A. *Physical strains*						
1. Average force (lb.)	—	—	M	50	—	—
2. Posture	L	4	M	6	L	2
3. Vibration	L	2	L	—	—	—
4. Short cycle	H	10	L	—	—	—
5. Restrictive clothing	—	—	—	—	—	—
B. *Mental strains*						
1. Concentration/anxiety	M	6	L	1	H	10
2. Monotony	M	6	L	1	L	2
3. Eye strain	L	3	—	—	L	2
4. Noise	M	4	L	—	L	1
C. *Working conditions*						
1. Temperature/humidity	—	—	L/L	1	L/L	3
2. Ventilation	—	—	—	—	—	—
3. Fumes	—	—	—	—	—	—
4. Dust	—	—	H	9	—	—
5. Dirt	M	3	L	—	—	—
6. Wet	—	—	L	—	—	—
Total points		38		68		20
Relaxation allowance, including tea breaks (percent)		18		35		13

ANNEX C

(*Clause* 7.3.3.2)

WORK SAMPLING RECORD SHEETS

C-1 EXAMPLE OF A SIMPLE WORK SAMPLING RECORD SHEET

Date: Observer:		Study No.:	
Number of observations: 75		Total	Percentage
Machine running	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍷𝍷	62	82.7
Machine idle	𝍸 𝍸 𝍷𝍷𝍷	13	17.3

C-2 WORK SAMPLING RECORD SHEET SHOWING MACHINE UTILISATION AND DISTRIBUTION OF IDLE TIME

Date: Observer:			Study No.:	
Number of observations: 75			Total	Percentage
Machine running		𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍷𝍷	62	82.7
Machine idle	Repairs	𝍷𝍷	2	2.7
	Supplies	𝍸 𝍷	6	8.0
	Personal	𝍷	1	1.3
	Idle	𝍷𝍷𝍷𝍷	4	5.3

C-3 WORK SAMPLING RECORD SHEET SHOWING DISTRIBUTION OF TIME ON TEN ELEMENTS OF WORK PERFORMED BY A GROUP OF FOUR WORKERS

Date: Observer:						Study No.:				
Number of observations:										
	Elements of work									
	1	2	3	4	5	6	7	8	9	10
Worker No. 1										
Worker No. 2										
Worker No. 3										
Worker No. 4										

ANNEX D

(*Clause* 7.3.3.4)

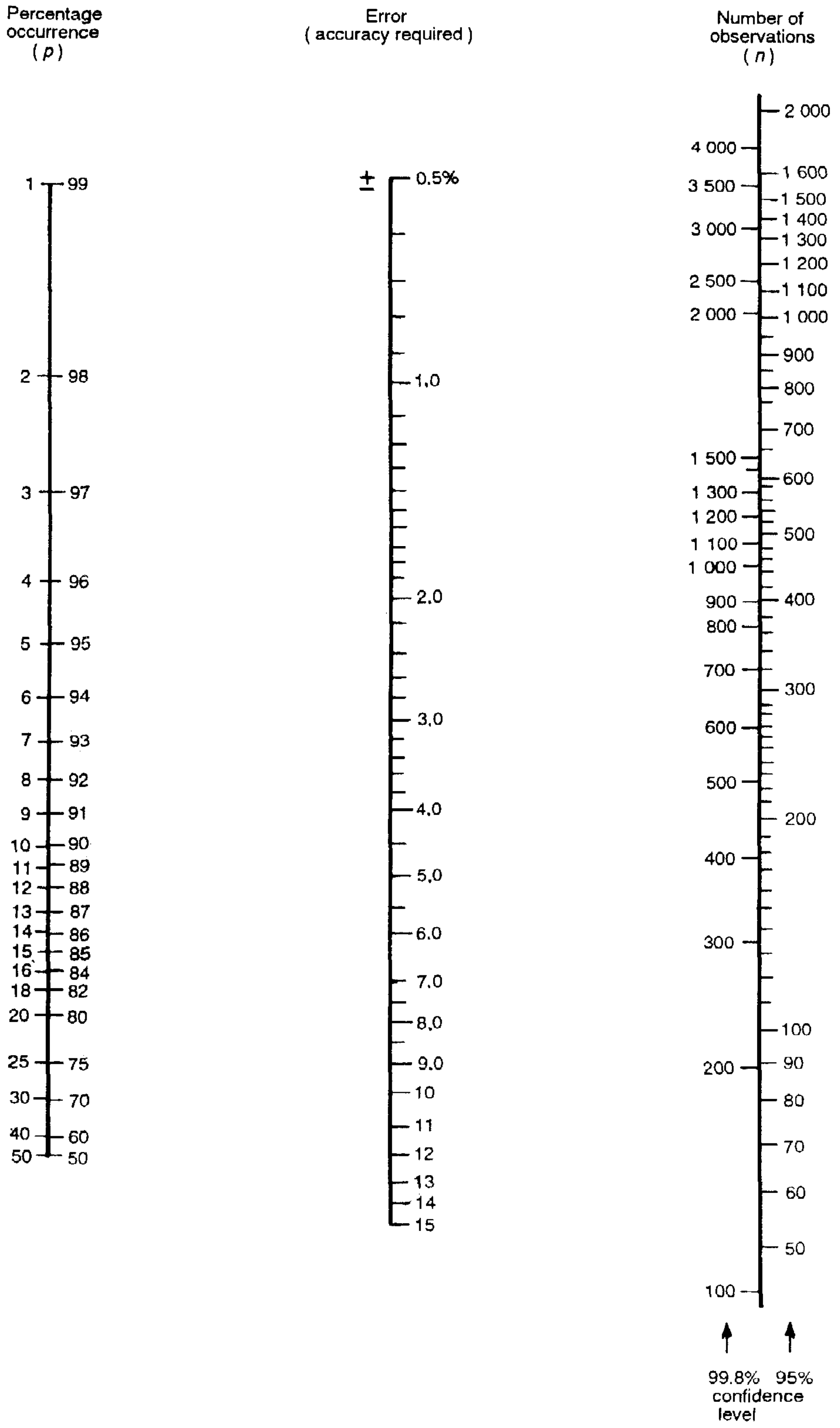
TABLE OF RANDOM NUMBERS

49 54 43 54 82	17 37 93 23 78	87 35 20 96 43	84 26 34 91 64
57 24 55 06 88	77 04 74 47 67	21 76 33 50 25	83 92 12 06 76
16 95 55 67 19	98 10 50 71 75	12 86 73 58 07	44 39 52 38 79
78 64 56 07 82	52 42 07 44 38	15 51 00 13 42	99 66 02 79 54
09 47 27 96 54	49 17 46 09 62	90 52 84 77 27	08 02 73 43 28
44 17 16 58 09	79 83 86 19 62	06 76 50 03 10	55 23 64 05 05
84 16 07 44 99	83 11 46 32 24	20 14 85 88 45	10 93 72 88 71
82 97 77 77 81	07 45 32 14 08	32 98 94 07 72	93 85 79 10 75
50 92 26 11 97	00 56 76 31 38	80 22 02 53 53	86 60 42 04 53
83 39 50 08 30	42 34 07 96 88	54 42 06 87 98	35 85 29 48 39
40 33 20 38 26	13 89 51 03 74	17 76 37 13 04	07 74 21 19 30
96 83 50 87 75	97 12 25 93 47	70 33 24 03 54	97 77 46 44 80
88 42 95 45 72	16 64 36 16 00	04 43 18 66 79	94 77 24 21 90
33 27 14 34 09	45 59 34 68 49	12 72 07 34 45	99 27 72 95 14
50 27 89 87 19	20 15 37 00 49	52 85 66 60 44	38 68 88 11 80
55 74 30 77 40	44 22 78 84 26	04 33 46 09 52	68 07 97 06 57
59 29 97 68 60	71 91 38 67 54	13 58 18 24 76	15 54 55 95 52
48 55 90 65 72	96 57 69 36 10	96 46 92 42 45	97 60 49 04 91
66 37 32 20 30	77 84 57 03 29	10 45 65 04 26	11 04 96 67 24
68 49 69 10 82	53 75 91 93 30	34 25 20 57 27	40 48 73 51 92
83 62 64 11 12	67 19 00 71 74	60 47 21 29 68	02 02 37 03 31
06 09 19 74 66	02 94 37 34 02	76 70 90 30 86	38 45 94 30 38
33 32 51 26 38	79 78 45 04 91	16 92 53 56 16	02 75 50 95 98
42 38 97 01 50	87 75 66 81 41	40 01 74 91 62	48 51 84 08 32
96 44 33 49 13	34 86 82 53 91	00 52 43 48 85	27 55 26 89 62
64 05 71 95 86	11 05 65 09 68	76 83 20 37 90	57 16 00 11 66
75 73 88 05 90	52 27 41 14 86	22 98 12 22 08	07 52 74 95 80
33 96 02 75 19	07 60 62 93 55	59 33 82 43 90	49 37 38 44 59
97 51 40 14 02	04 02 33 31 08	39 54 16 49 36	47 95 93 13 30
15 06 15 93 20	01 90 10 75 06	40 78 78 89 62	02 67 74 17 33
22 35 85 15 33	92 03 51 59 77	59 56 78 06 83	52 91 05 70 74
09 98 42 99 64	61 71 62 99 15	06 51 29 16 93	58 05 77 09 51
54 87 66 47 54	73 32 08 11 12	44 95 92 63 16	29 56 24 29 48
58 37 78 80 70	42 10 50 67 42	32 17 55 85 74	94 44 67 16 94
87 59 36 22 41	26 78 63 06 55	13 08 27 01 50	15 29 39 39 43
71 41 61 50 72	12 41 94 96 26	44 95 27 36 99	02 96 74 30 83
23 52 23 33 12	96 93 02 18 39	07 02 18 36 07	25 99 32 70 23
31 04 49 69 96	10 47 48 45 88	13 41 43 89 20	97 17 14 49 17
31 99 73 68 68	35 81 33 03 76	24 30 12 48 60	18 99 10 72 34
94 58 28 41 36	45 37 59 03 09	90 35 57 29 12	82 62 54 65 60

ANNEX E

(*Clause* 7.3.3.5)

NOMOGRAM FOR DETERMINING NUMBER OF OBSERVATIONS



ANNEX F

(*Clause* 7.5.5.2)

WORKPLACE LAYOUT SHEETS

F-1 ASSEMBLY METHOD SHEET

DEPT.: SHEET OF:

Job No.: Job Description: Operation No.: Operation: Fixture No.: Fixture:

COMPONENT DETAILS

SL NO.	COMPONENT NO.	COMPONENT DESCRIPTION	LOCATION ON W/P LAYOUT

WORK TABLE
(800 × 1 200 mm)

WORK PLACE LAYOUT OPERATOR SCALE: 1: 10

ASSEMBLY INSTRUCTIONS

SL NO.	DESCRIPTION		REMARKS
	LEFT HAND	RIGHT HAND	

PREPARED BY:
DATE:

CHECKED BY:
DATE :

APPROVED BY:
DATE :

F-2 MTM ANALYSIS SHEET

ELEMENT ANALYSIS

SHEET NO.: ____

JOB: ______________________________ STUDY NO.: ____________

______________________________ DATE: ____________

OPERATOR: ______________________________

L.H. DESCRIPTION	F	MOTION	TMU	MOTION	F	R.H. DESCRIPTION

STUDIED BY: ____________

ANNEX G

(*Clause* 7.5.5.3)

MTM—APPLICATION DATA IN TMU

G-1 TURN-T

Symbol	*Weight in kg*	*Angle turned in degrees*										
		30	45	60	75	90	105	120	135	150	165	180
S	Small 0 to 1 kg	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.6
M	Medium 1.1 to 5 kg	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
L	Large 5.1 to 16 kg	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	24.3	26.1	28.2

G-2 BODY, LEG AND FOOT MOTIONS

Symbol	*TMU*	*Length of Motion*	*Description*
FM	8.5	Up to 10 cm	Foot-Motion
FMP	19.1		Foot-Motion with heavy pressure
LM	7.1	Up to 15 cm	Leg-Motion
	0.5	For each cm additional	
			Side step: Side displacement of body axis.
SS-C1	17.0	Up to 30 cm	Case 1 The side step ends, when leading leg contacts floor.
	0.2	For each cm additional	
SS-C2	34.1	Up to 60 cm	Case 2 Lagging leg must contact floor before next motion can be made.
	0.2	For each cm additional	
			Turn body 45° to 90°—Right or Left
TB-C1	18.5		Case 1 Complete when leading leg contacts floor.
TB-C2	37.2		Case 2 Lagging leg must contact floor before next motion can be made.
B.S. KOK	29.0		Bend, Stop, Kneel on one knee
AB. AS. AKOK	31.9		Arise
KBK	69.4		Kneel on both knees
AKBK	76.7		Arise
SIT	34.7		Sit
STD	43.4		Stand
W-P	15.0	Per. pace	Walk
W-PO	17.0	Per. pace	Walk—Obstructed
W-PL	17.0	Per. pace	Walk—With load

G-3 CRANK C

Crank ϕ in cm	2	4	6	8	10	12	14	16	18	20	Value for Acceleration and Retardation 5.2 TMU
TMU/Revolution	8.2	9.2	10.0	10.7	11.3	11.9	12.4	12.8	13.2	13.6	
Crank ϕ in cm	22	24	26	28	30	35	40	45	50	>50	
TMU/Revolution	13.9	14.2	14.5	14.8	15.0	15.5	16.0	16.4	16.7	Move	

The values do not include time for acceleration and retardation

G-4 MTM NORMAL TIME VALUE CARD

Do not attempt to use this chart or apply methods—Time measurement in any way unless you understand the proper application of the data. This statement is included as a word of caution to prevent difficulties resulting from misapplication of the data.

	Time Units			
	TMU	Second	Minute	Hour
The normal time values of this card are current for basic motions which are performed with normal degree of effort (100%)	1	0.036	0.000 6	0.000 01
	27.8	1	—	—
	1 666.7	—	1	—
	100 000	—	—	1

G-5 SIMULTANEOUS MOTIONS

			Reach			Move			Grasp			Position			Disengage	
			AE	*B*	*C, D*	*A, Bm*	*B*	*C*	*G1A, G2, G5*	*G1B, G1C*	*G4*	*P1S*	*P1SS, P2S*	*P1NS, P2SS, P2NS*	*D1E, D1D*	*D2*
Disengage	*D2*	*D*		X	■		X	■	■	■	■	■	■	■		
		E			■			■	■	■	■	■	■	■		
	D1E, D1D				X			X		■	■	■	■	■		
Position	*P1NS* *P2SS* *P2NS*	*D*	X	■	■	X	■	■	■	■	■	■	■	■		
		E	X	■	■	X	■	■	■	■	■	■	■	■		
	P1SS *P2S*	*D*	X	■	■	X	■	■	■	■	■	■	■			
		E		X	■		X	■		■	■	■	■			
	P1S	*D*		X	■		X	■		■	■	■				
		E		X	■		X	■		■	■	X				
Grasp	*G4*	*O*		■	■		■	■		■	■					
		W		X	■		X	■		X	■					
	G1B *G1C*	*O*		X	■		X	■		■						
		W			X			X		■						
	G1A, G2, G3															
Move	*C*	*O*	X	■	■			■								
		W	X	X	■			X								
	B	*O*		X	■											
		W			X											
	A, Bm	*O*			■											
		W			X											
Reach	*C,D*	*O*		X	X											
		W														
	B															
	A E															

☐ = Easy

☒ = Practice

■ = Difficult

W = Within the area of normal vision.

O = Outside the area of normal vision.

E = Easy to handle.

D = Difficult to handle.

Motions not included in the above table.

T = Turn: Normally easy with all motions except when turn is controlled or with disengage.

AP = Apply Pressure: Each case to be analysed.

P3 = Position: Always difficult.

D3 = Disengage: Normally difficult.

RL = Release: Always easy.

G-6 EYE—TRAVEL—ET

NORMAL TIME VALUE IN TMU		
	TMU	*Description*
ET	$15.2 \times \frac{T}{D}$	*T* = Distance between points from and to which eye travels *D* = Perpendicular Distance from Eye to Line of travel
		Max Value = 20 TMU

G-7 EYE—FOCUS—EF

Normal Time Value for Eye Focus = 7.3 TMU

G-8 REACH—R

NORMAL TIME IN TMU								
Distance Move in cms	*R—A*	*R—B*	*R—C* *R—D*	*R—E*	*mR—A* *R—Am*	*mR—B* *R—Bm*	*m Value for B*	*Description of the Cases*
2 or Less	2.0	2.0	2.0	2.0	1.6	1.6	0.4	*A* Reach to object in fixed location or to object in other hand or on which other hand rests.
4	3.4	3.4	5.1	3.2	3.0	2.4	1.0	
6	4.5	4.5	6.5	4.4	3.9	3.1	1.4	
8	5.5	5.5	7.5	5.5	4.6	3.7	1.8	
10	6.1	6.3	8.4	6.8	4.9	4.3	2.0	
12	6.4	7.4	9.1	7.3	5.2	4.8	2.6	*B* Reach to single object in location which may vary slightly from cycle to cycle.
14	6.8	8.2	9.7	7.8	5.5	5.4	2.8	
16	7.1	8.8	10.3	8.2	5.8	5.9	2.9	
18	7.5	9.4	10.8	8.7	6.1	6.5	2.9	
20	7.8	10.0	11.4	9.2	6.5	7.1	2.9	
22	8.1	10.5	11.9	9.7	6.8	7.7	2.8	*C* Reach to object jumbled with other objects in a group so that search and select occur.
24	8.5	11.1	12.5	10.2	7.1	8.2	2.9	
26	8.8	11.7	13.0	10.7	7.4	8.8	2.9	
28	9.2	12.2	13.6	11.2	7.7	9.4	2.8	
30	9.5	12.8	14.1	11.7	8.0	9.9	2.9	*D* Reach to a very small object or where accurate grasp is required.
35	10.4	14.2	15.5	12.9	8.8	11.4	2.8	
40	11.3	15.6	16.8	14.1	9.6	12.8	2.8	
45	12.1	17.0	18.2	15.3	10.4	14.2	2.8	
50	13.0	18.4	19.6	16.5	11.2	15.7	2.7	*E* Reach to indefinite location to get hand in position for body balance or next motion or out of way.
55	13.9	19.8	20.9	17.8	12.0	17.1	2.7	
60	14.7	21.2	22.3	19.0	12.8	18.5	2.7	
65	15.6	22.6	23.6	20.2	13.5	19.9	2.7	
70	16.5	24.1	25.0	21.4	14.3	21.4	2.7	
75	17.3	25.5	26.4	22.6	15.1	22.8	2.7	
80	18.2	26.9	27.7	23.9	15.9	24.2	2.7	

G-9 GRASP—G

Symbol	*TMU*	*Description*	
G1A	2.0	Pick up grasp—small, medium or large object by itself, easily grasped.	
G1B	3.5	Very small object or object lying close against a flat surface.	
G1C1	7.3	> 12 mm ϕ	Interference with grasp on bottom and one side of nearly cylindrical object.
G1C2	8.7	6 to 12 mm ϕ	
G1 C3	10.8	< 6 mm ϕ	
G2	5.6	Regrasp: Displace object without loosening the control over it.	
G3	5.6	Transfer grasp from one hand to the other. One hand takes over the control, the other hand releases.	
G4A	7.3	> 25 × 25 × 25 mm	Object jumbled with other objects so that search and select occur Select grasp
G4B	9.1	6 × 6 × 3 to 25 × 25 × 25 mm	
G4C	12.9	< 6 × 6 × 3 mm	
G5	0.0	Contact, Hook or Sliding Grasp: To gain sufficient control over an object so that the next basic motion may be employed.	

G-10 RELEASE—

Symbol	*TMU*	*Description*	*Symbol*	*TMU*	*Description*
RL 1	2.0	Release by opening fingers	RL 2	0.0	Contact release

G-11 MOVE—M

Distance Moved in cms	*Normal time in TMU*					*Weight Allowance*			*Description of the Cases*
	M—A	*M—B*	*M—C*	*mM—B* *M—Bm*	*m* Value for *B*	Weight up to kg	Factor *W*	Constant *K*	
2 or Less	2.0	2.0	2.0	1.7	0.3	1	1.00	0.0	*A* Move object to other hand or against stop.
4	3.1	4.0	4.5	2.8	1.2				
6	4.1	5.0	5.8	3.1	1.9	2	1.04	1.6	
8	5.1	5.9	6.9	3.7	2.2				
10	6.0	6.8	7.9	4.3	2.5	4	1.07	2.8	
12	6.9	7.7	8.8	4.9	2.8				
14	7.7	8.5	9.8	5.4	3.1	6	1.12	4.3	
16	8.3	9.2	10.5	6.0	3.2				
18	9.0	9.8	11.1	6.5	3.3	8	1.17	5.8	*B* Move object to approximate or definite location.
20	9.6	10.5	11.7	7.1	3.4				
22	10.2	11.2	12.4	7.6	3.6	10	1.22	7.3	
24	10.8	11.8	13.0	8.2	3.6				
26	11.5	12.3	13.7	8.7	3.6	12	1.27	8.8	
28	12.1	12.8	14.4	9.3	3.5				
30	12.7	13.3	15.1	9.8	3.5	14	1.32	10.4	
35	14.3	14.5	16.8	11.2	3.3				
40	15.8	15.6	18.5	12.6	3.0	16	1.36	11.9	*C* Move object to an exact location.
45	17.4	16.8	20.1	14.0	2.8				
50	19.0	18.0	21.8	15.4	2.6	18	1.41	13.4	
55	20.5	19.2	23.5	16.8	2.4				
60	22.1	20.4	25.2	18.2	2.2	20	1.46	14.9	
65	23.6	21.6	26.9	19.5	2.1				
70	25.2	22.8	28.6	20.9	1.9	22	1.51	16.4	
75	26.7	24.0	30.3	22.3	1.7				
80	28.3	25.2	32.0	23.7	1.5				

G-12 POSITION—P

Symbol	*Class of Fit*	*Description*	*Align* mm	*Symmetry*	*To Handle*	
					Easy	Difficult
P1	Loose	No pressure required	≤ ±6.0	S	5.6	11.2
				SS	9.1	14.7
				NS	10.4	16.0
P2	Close	Light pressure required	≤ ±1.5	S	16.2	21.8
				SS	19.7	25.3
				NS	21.0	26.6
P3	Exact	Heavy pressure required	≤ ±0.4	S	43.0	48.6
				SS	46.5	52.1
				NS	47.8	53.4

G-13 APPLY—PRESSSURE—AP

Symbol	*TMU*	*Description*	*Symbol*	*TMU*	*Description*	*Symbol*	*TMU*	*Description*
AP1	16.2	With regrasp	AP2	10.6	Without regrasp	AP 3	5.4	Dwell (unofficial)

G-14 DISENGAGE —D

Symbol	*Class of Fit*	*Description*	*To Handle*	
			Easy	Difficult
D1	Loose	Very slight effort — minimum recoil	4.0	5.7
D2	Close	Normal effort-slight recoil up to 10 cms	7.5	11.8
D3	Tight	Considerable effort—Marked recoil over 10 cms	22.9	34.7

ANNEX H

(*Foreword*)

COMMITTEE COMPOSITION

Management and Productivity Sectional Committee, MSD 4

Chairman	*Representing*
Shri T. K. Gupta	Bharat Heavy Electricals Limited, New Delhi
Members	
Shri N. C. Agrawal	Bajaj Auto Limited, Pune
Shri M. L. Katyal (*Alternate*)	
Shri S. C. Chakraborty	Indian Statistical Institute, New Delhi
Shri V. K. Chaturvedi	Oil & Natural Gas Commission, Dehradun
Shri P. K. Bahl (*Alternate*)	
Brig M. L. Garg, AVSM, Kirti Chakra	G. Management Services Pvt Ltd, New Delhi
Shri B. P. Bajpayee (*Alternate*)	
Shri O. P. Goyal	Straw Products Limited, New Delhi
Shri K. G. Gopalakrishnan (*Alternate*)	
Shri O. P. Gupta	National Productivity Council, New Delhi
Shri B. P. Dhaka (*Alternate*)	
Shri S. C. Gupta	Directorate General Factory Advice and General/Labour Institute, Ministry of Labour, Bombay
Shri E. Laxminarayana (*Alternate*)	
Shri P. R. Kothari	Larsen & Toubro Limited, Bombay
Shri A. A. Kurlekar	Tata Engineering and Locomotive Co Ltd, Dehradun
Shri S. P. Sarkar (*Alternate*)	
Cdr D. D. Loomba	Naval Headquarters, Ministry of Defence, New Delhi
Shri R. P. S. Luther	Engineers India Limited, New Delhi
Dr J. M. Mahajan	Indian Institute of Technology, New Delhi
Shri A. D. Gupta (*Alternate*)	
Dr Thomas Mathew	Indian Institution of Industrial Engineering, Bombay
Shri M. V. Narayanan (*Alternate*)	
Prof Thomas Mathew	National Institute for Training in Industrial Engineering, Bombay
Dr B. S. Moulik	The Associated Cement Companies Limited, Thane
Shri V. J. Ananthramana (*Alternate*)	
Brig U. S. Narula	Deputy Directorate General of Management Studies, Army Headquarters, New Delhi
Col P. K. Chopra (*Alternate*)	
Shri S. Palit	Indian Jute Industries' Research Association, Calcutta
Shri G. Chatterji (*Alternate*)	
Shri Daya Prakash	Ordnance Factory Board, Calcutta
Shri D. I. Shrivastava (*Alternate*)	
Shri J. K. Puri	The Institute of Cost and Works Accountants of India, New Delhi
Shri D. C. Bajaj (*Alternate*)	
Col L. Ramrakhiani	College of Defence Management, Ministry of Defence, Secunderabad
Cdr I. Mathew (*Alternate*)	
Shri P. S. Rao	Pieco Electronics and Electricals Limited (Philips), Bombay
Shri E. R. Batliwala (*Alternate*)	
Prof R. K. Sachdeva	Indian Institute of Public Administration, New Delhi
Shri M. P. Sethy	Institute of Secretariat Training and Management, New Delhi
Shri S. Venkatesan (*Alternate*)	
Shri D. L. Sharma	All India Management Association, New Delhi
Shri J. S. Sharma	Central Building Research Institute (CSIR), New Delhi
Shri G. C. Sofat (*Alternate*)	
Shri R. C. Suri	Defence Institute of Work Study, Mussoorie
Shri V. K. Devgan (*Alternate*)	
Shri K. M. Thomas	Ministry of Railways, Vadodara
Shri S. C. Agnihotri (*Alternate*)	
Shri S. S. Venkataramanan	Venconvave Pvt Ltd, New Delhi
Shri A. S. Viswanathan	Siemens Limited, Thane
Shri S. S. Jaswal (*Alternate*)	
Shri D. S. Ahluwalia, Director (MSD)	Director General, BIS (*Ex-officio Member*)

Member-Secretary
Shrimati Renu Gupta
Assistant Director (MSD), BIS

Panel for 'Techniques of Work Study (Part 2) : Work Measurement' (MSD 4/P-1)

Convener	
Shri S. S. Jaswal	Siemens Limited, Thane
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